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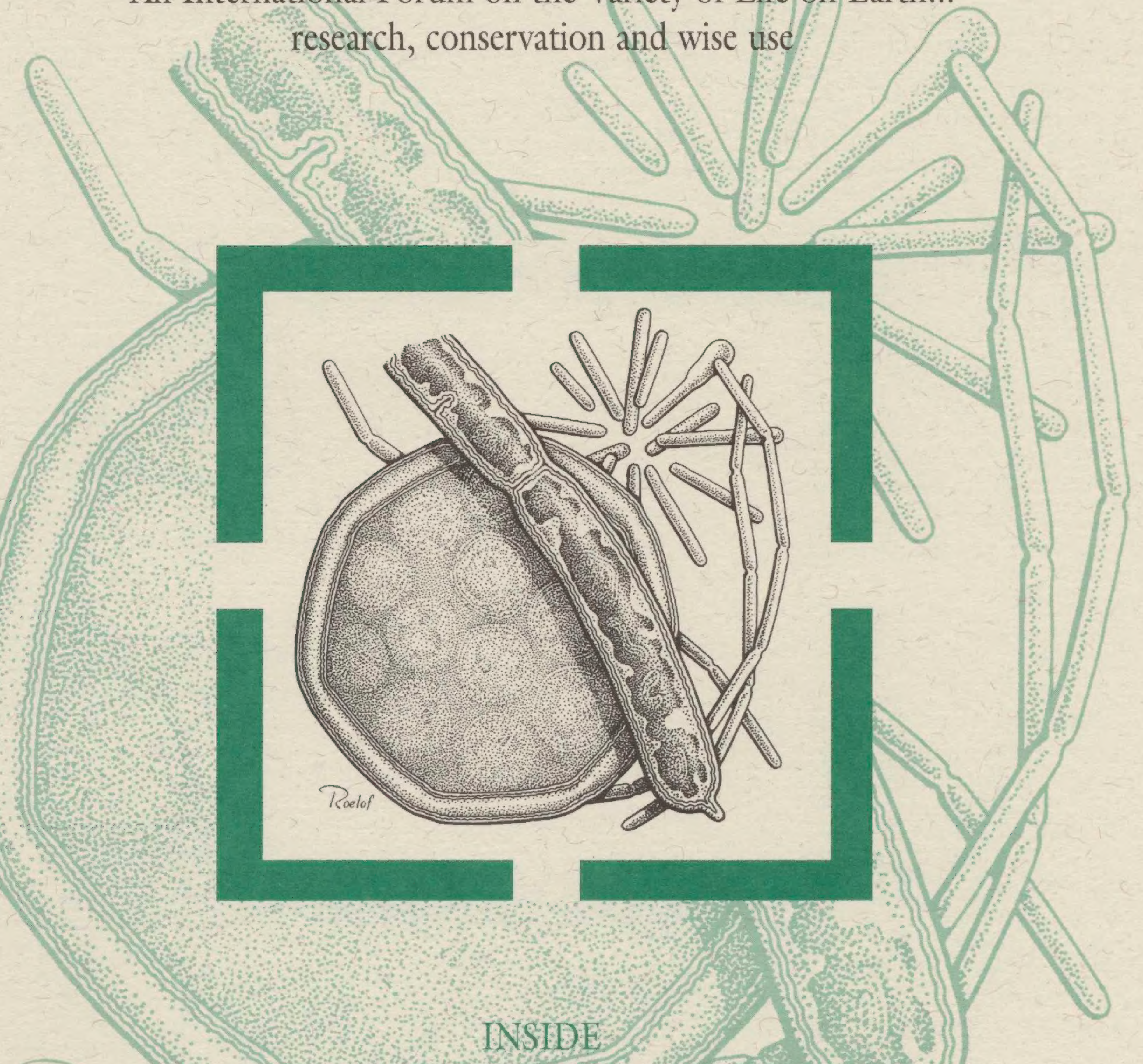
■ CANADIAN MUSEUM OF NATURE ■

Global biodiversity

An International Forum on the Variety of Life on Earth...
research, conservation and wise use



INSIDE
Al Gore on climate control
■
Agroforestry
■
Investigating microbial diversity

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Editor's Notebook

OUR ENVIRONMENTAL DEBT

Governments in North America and elsewhere, pushed by corporate and conservative fiscal forces, have made reduction of national financial debts their priority. There is no doubt that national debts and debt payments in many countries, due in large measure to expenditure on non-productive armaments, present a heavy drain on national budgets.

But there are other kinds of debts that may be as critical or more critical to a nation's survival. Social debts include the education and health programs foregone in the name of "fiscal realities" or the "restructuring" that the world or regional banks impose on countries in economic difficulties. These social debts reduce the productive capacity of a nation as well as the quality of life of the people.

Another kind of debt is environmental. Environmental debts are incurred when natural capital is destroyed or degraded. Some examples explain. The plowing down of sensitive short grass prairies led to the Dust Bowl of the 1930s, where millions of tonnes of soil, previously anchored by grass roots, were blown away. Even today 58 million metric tonnes of U.S. soil are dropped into the ocean each year. (See J.M. Johnston's article in this issue, page 7.) The overharvesting of fish stocks, habitat degradation, and other actions (*Sea Wind* 8(2): 2-9, 1994) left no precautionary margin when ocean waters cooled. Fifty thousand jobs were lost as well as $224 million from the annual cod harvest due to overharvesting (*Canada's Biodiversity*, in press). Degradation of coral reefs in the Philippines has been estimated to have lost 127,000 small-scale fishing jobs and cost $100 million per year in lost catches (*Galaxea* 7: 161-178, 1988). For other costs see U.S. Vice-President Al Gore's article on page 18 of this issue.

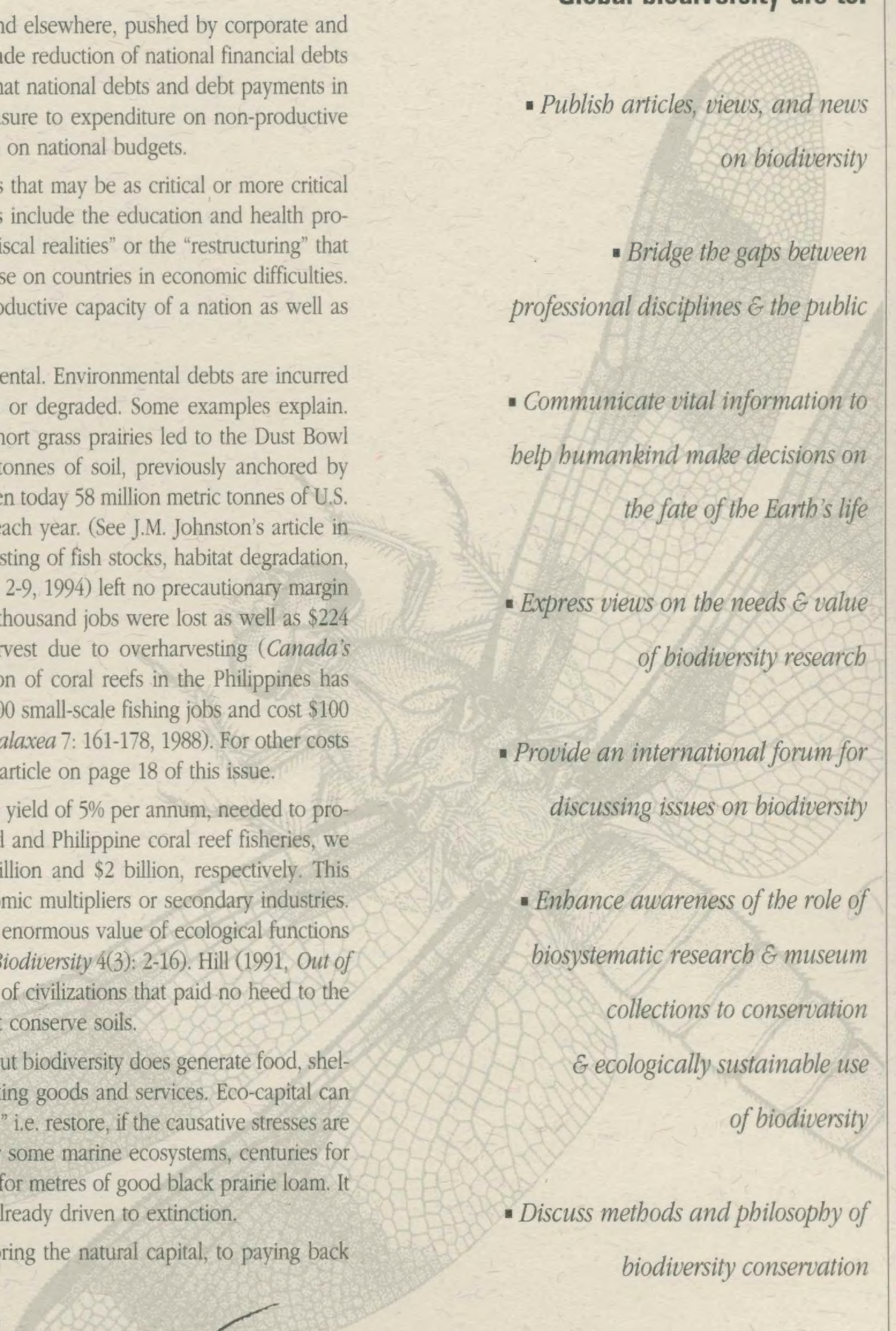
If we consider the investment at a yield of 5% per annum, needed to produce the value of the Atlantic cod and Philippine coral reef fisheries, we estimate capital values of $5.3 billion and $2 billion, respectively. This does not take into account economic multipliers or secondary industries. Nor does it take into account the enormous value of ecological functions or ecoservices (Mosquin, *Global Biodiversity* 4(3): 2-16). Hill (1991, *Out of the Earth*) documents the demise of civilizations that paid no heed to the need to protect the processes that conserve soils.

We cannot eat or breath money. But biodiversity does generate food, shelter, oxygen and other life supporting goods and services. Eco-capital can take lengthy periods to "pay back," i.e. restore, if the causative stresses are removed. This means decades for some marine ecosystems, centuries for old growth forests, and millennia for metres of good black prairie loam. It means forever for those species already driven to extinction.

Let's give highest priority to restoring the natural capital, to paying back our *environmental* debt.

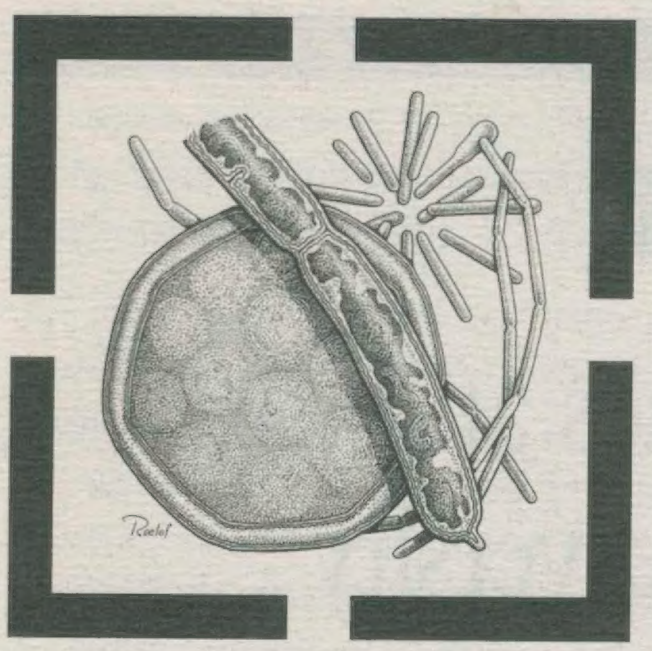
Don E. McAllister

Don E. McAllister
Editor



The goals of Global biodiversity are to:

- *Publish articles, views, and news on biodiversity*
- *Bridge the gaps between professional disciplines & the public*
- *Communicate vital information to help humankind make decisions on the fate of the Earth's life*
- *Express views on the needs & value of biodiversity research*
- *Provide an international forum for discussing issues on biodiversity*
- *Enhance awareness of the role of biosystematic research & museum collections to conservation & ecologically sustainable use of biodiversity*
- *Discuss methods and philosophy of biodiversity conservation*
- *Review books and major articles on biodiversity*



The cover art shows three forms of *Thermus aquaticus*, a bacterium first found in Yellowstone National Park in 1965. For more on this bacterium, see page 5 and page 16.

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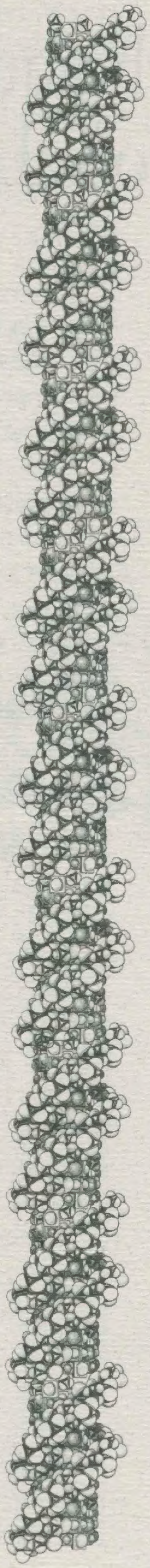


PAPERS

Nucleic acid techniques and the study of microbial diversity 2
by Tom Edge and Cam Wyndham

Agroforestry: We owe it to our children 7
by Jana M. Johnston

How many trees make a forest? Brazilian rainforest research 12
by Biodiversity Programs, Smithsonian Institution

A PORTRAIT OF BIODIVERSITY

Thermus aquaticus 16

VIEWS

Consequences of transgressing human laws and nature's laws . . 17
by Don E. McAllister

U.S. Vice-President Al Gore on climate control 18
by Al Gore

Educating the public about biodiversity 24
by Raymond Chipeniuk

Biodiversity education: Intuitive cognition is far from enough! . . 27
by Claude Villeneuve

The Mission of the U.S. National Biological Service 29
by H. Ronald Pulliam

How will climate change affect taiga underlain by permafrost? . . 33
by Don E. McAllister

NEWS

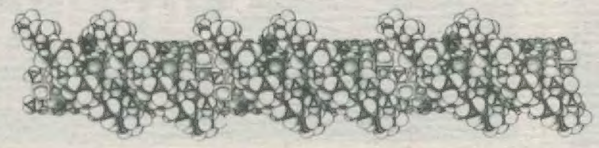
Biodiversity news 34
Cyberdiversity: Biodiversity and the Internet 39
Biodiversity meetings 41

REVIEWS

Book and Periodical Niche 42

THE LAST WORD

Even ecosystems grow old... 48
by Alan R. Emery



Nucleic acid techniques and the study of microbial diversity

Molecular techniques are especially important in the study of microbial diversity, given the difficulty of distinguishing species and relationships with microscopic methods. At the same time molecular techniques will provide new knowledge to drive industries well into the next millenium. [D.E.M.]

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INTRODUCTION

The United Nations Convention on Biological Diversity has drawn increasing attention to the ecological and economic importance of biodiversity. However, this attention has been largely directed at the diversity of plants and animals. Comparatively little attention has been focused on the importance of microbial diversity.

Microorganisms were the first forms of life on Earth, and they continue to play a far more important ecological role in natural environments than their small size would suggest. Microorganisms are also economically important; they are used to produce hundreds of commercial products valued in the tens of billions of dollars worldwide (Steele and Stowers, 1991). Despite their importance, the diversity of microorganisms is poorly understood.

Progress in understanding microbial diversity has been slower than that for higher organisms because it has been more dependent on novel physical and chemical techniques. The small size of microorganisms rules out most of the direct approaches used to study macroorganisms. However, the application of nucleic acid techniques is now enabling the discovery of unknown groups of microorganisms and is revealing the extent of genetic diversity within known microbial taxa. The application of these techniques is catalyzing an explosion of knowledge and an understanding of microbial diversity (Bull, 1994).

NUCLEIC ACID TECHNIQUES FOR STUDYING MICROBIAL DIVERSITY

It has been difficult to study the diversity of natural microbial populations because one could only select and identify the microorganisms able to grow under imposed culturing conditions. This has been a significant problem since it has been estimated that, for some habitats, as many as 99% of bacterial species are not readily recovered by conventional techniques (Atlas and Bartha, 1993). However, by studying molecules from microorganisms in the environment, rather than the organisms themselves, the need for culturing can be circumvented.

The development of molecular techniques has been described as a turning point in microbial ecology, enabling a better understanding of the structure and metabolic activities of microbial communities. The first molecular techniques used to define microbial community structure were largely restricted to analyses of biochemical markers such as lipids and carbohydrates in cell envelopes and membranes. While these markers offer some categorization of populations, they are limited to known biochemical markers. Novel constituents, representing unknown microorganisms, could not be interpreted (Stahl *et al.*, 1985).

The development of nucleic acid techniques, however, provided powerful new ways to study microbial diversity (Holben and Tiedje, 1988). Nucleic acids can be found in all organisms. They are long polymers, such as deoxyribonucleic acid (DNA) or ribonucleic acid (RNA), in which molecules called nucleotides are bonded to one another in a defined sequence. Techniques for analyzing these nucleic acids are proving valuable in determining the role of the environment in gene expression, the extent of gene transfer among microbial populations in the environment, and the taxonomic relationships among microbial community members. The adoption of these innovative techniques is also transforming the ability to detect and understand the genetic and species diversity of microorganisms in the environment. Leung *et al.* (1994) recently reviewed genetic approaches to studying bacterial diversity and included the following key nucleic acid techniques.

DNA reassociation

DNA reassociation methods can be applied to measure the *in situ* genetic diversity of a microbial community. DNA from organisms in the environment can be melted and then allowed to reassociate upon cooling. The rate of reassociation of denatured DNA is inversely related to the complexity of DNA being analyzed. Using this method, the diversity of a microbial population can be expressed in terms of the time for the denatured DNA to reassociate. Longer reassociation times may be required for renaturing of very long molecules and entire genomes.

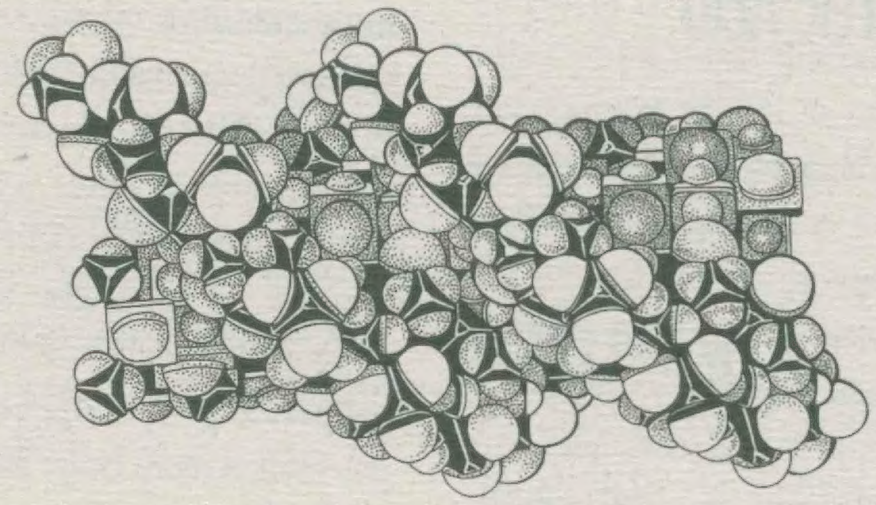
DNA probing

DNA probes are molecules of single-stranded DNA that have been labeled, chemically or radioactively, so that they can be detected in a mixture of reassociated DNA (Knight *et al.*, 1992). The probe is added to a sample of denatured DNA and, under appropriate conditions, hybridizes with regions of the sample DNA that are complementary. The probe-target DNA hybrids are then detected by methods appropriate to the way the probe was labeled.

DNA probing can be a powerful method for studying the genetic diversity of DNA extracts obtained directly from the environment and for revealing particular microbial species or other components of microbial diversity within the total DNA pool of a sample. A specific DNA sequence or gene can be detected without the need for gene expression for monitoring purposes. This is important considering only a small component of the microbial community in an environmental sample is likely to be growing rapidly at any time, and thus, only a fraction of the population may be actively expressing genes that could serve to detect the organism.

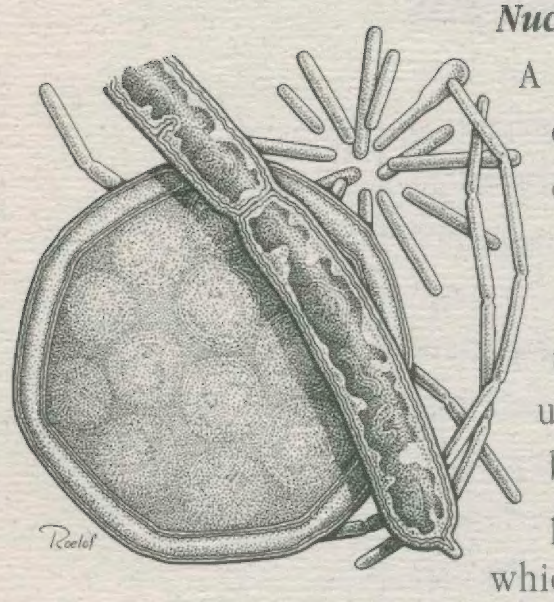
RNA probing

Similar to DNA probing, ribosomal RNA (rRNA) probes can be a powerful nucleic acid technique for studying microbial diversity and phylogenetic or evolutionary relationships. rRNA occurs in all organisms and demonstrates valuable qualities of universality, genetic stability, and conservation of structure. Most regions of the 5s, 16s, and 23s rRNA molecules are highly conserved, and therefore, hybridization can be used to distinguish distantly related organisms up to the kingdom or domain level. Other regions of the rRNA molecules are more variable, and can be used to distinguish relatively closely related organisms, e.g. at the species level (Lee and Fuhrman, 1990). rRNA probes can also be designed to study the ecology of different phylogenetic groups of microorganisms (Stahl and Amann, 1991).



This is a space filling drawing of a fragment of the polynucleotide chain of a double-helical DNA molecule.

rRNA-directed probes can be much more sensitive than DNA-directed probes (Knight *et al.*, 1992). While a single cell may have only one or several copies of a chromosomal DNA target, it can have up to 10,000 copies of an rRNA target. The number of copies depends on the stage of growth of the cell, which determines how many ribosomes it contains. By conjugating fluorescent dyes to rRNA probes, phylogenetic groups of bacteria can be identified and observed directly with a fluorescence microscope. rRNA probes can be designed using the information currently available in the Ribosomal RNA Database Project, which has released more than 450 full 16s rRNA sequences (Liesack and Stackebrandt, 1992).



Three forms of *Thermus aquaticus* are shown here.

Nucleic acid sequencing

A major breakthrough in determining the evolution and phylogeny of microorganisms came from the introduction of rRNA sequencing techniques. Comparisons of the sequences of nucleotides in 5s, 16s, and 23s rRNA molecules are currently among the most important data used to reveal phylogenetic relationships between microorganisms. These sequences are part of a steadily expanding database from which information can be retrieved whenever necessary (Stackebrandt and Liesack, 1993). For example, 16s rRNA genes of a DNA extract from nature can be sequenced and compared with existing 16s rDNA databases. Using this approach, novel groups of microorganisms, which could not be recovered by conventional culturing methods, can be identified.

SIGNIFICANT DISCOVERIES FROM APPLICATION OF NUCLEIC ACID TECHNIQUES

Many of the nucleic acid techniques discussed are still relatively new. Some have only been applied to questions in microbial ecology in the last four or five years. However, these techniques for studying microbial diversity have great potential. The following section describes three areas where nucleic acid techniques have already led to significant advances in our understanding of microbial diversity and its importance.

Extent of microbial diversity

The discovery of the unexpectedly large diversity of microorganisms occurring in nature has been one of the most significant advances. Even the microbial diversity already held in culture collections is likely greater than previously thought.

For example, Ward *et al.* (1990) and Barns *et al.* (1994) have recently examined rRNA sequences from microbial communities found in hot springs in Yellowstone National Park. They found many distinct sequence types, none of which were the same as those from the cultured microorganisms previously known to be associated with the well-studied hot springs. These authors concluded that the hot springs contained a remarkably large and diverse number of microorganisms that had never been cultured from this habitat before. Similarly, Giovannoni *et al.* (1990), Britschgi and Giovannoni (1991), and DeLong *et al.* (1994) have analyzed rRNA gene sequences of microorganisms from bacterioplankton in the Sargasso Sea and the Antarctic, and they have found that the species and genetic diversity within natural populations was far greater than indicated from using traditional culturing methods. These studies suggest that the majority of planktonic microorganisms remain unrecognized by microbiologists despite their importance in globally significant ecological processes.

Other nucleic acid techniques have also discovered a surprising amount of microbial diversity. Torsvik *et al.* (1990) used DNA reassociation methods to estimate there were about 4,000 different bacterial genomes in a one-gram sample of Norwegian soil. This diversity is equivalent to almost all the bacterial species described to date!

Phylogenetic or evolutionary basis for classifying microbial diversity

Another significant advancement has been the development of a new phylogenetic perspective for understanding microbial diversity. Early efforts at constructing a natural classification system for bacteria proved difficult. Bacterial properties upon which classification systems were based (e.g. morphology, motility, biochemical characteristics) were just too simple, variable, or otherwise uninterpretable to be phylogenetically reliable. With the advent of nucleic acid sequencing, phylogenetic relationships could be determined more easily and bacterial evolution became a subject that could be approached experimentally (Woese, 1987).

In the late 1970s, Carl Woese proposed a new way to classify organisms based on the sequences of rRNA. As previously stated, rRNAs occur in all organisms and demonstrate valuable qualities of universality, genetic stability, and conservation of structure. Different positions in their sequences evolve at very different rates allowing almost any phylogenetic relationship to be measured. The use of rRNA has led to a phylogenetic classification of bacteria, and perhaps, even more important, has provided a new paradigm for understanding the genetic diversity of life.

Woese's phylogenetic tree provides a cohesive superstructure to study microbial diversity.(See Figure 1 on page 5.) It represents a significant departure from what scientists thought were natural relationships among organisms even a decade or less ago and from what many students are still taught. The five kingdom picture

(Animals, Plants, Fungi, Protists, and Monera)—which is central to the teaching of biology in many schools today—is a distorted image of the genealogy of the living world (Woese, 1994). The new system includes three "domains," the *Eukarya, Archaea, Bacteria,* which classify all organisms above the kingdom level. These domains are based upon nucleic acid sequences that reveal evolutionary differences of a more profound nature between microorganisms in the Bacteria and Archaea than those that distinguish plants and animals. The domains also provide an additional framework of evolutionary relationships among living things.

While the applications of nucleic acid techniques have led to improved taxonomies, they have also contributed to the adoption of changes in nomenclature and better identification procedures. Techniques for the hybridization of nucleic acids have finally supplied bacteriologists with a useful tool to delineate species. The International Committee on Systematic Bacteriology recommends a minimum DNA similarity of 70% for the definition of a species, and DNA-DNA hybridization has become the gold standard for designation of bacterial species (Wayne *et al.*, 1987).

Economic value of microbial diversity

Another significant advance has been a growing recognition of the economic value of microbial diversity. While microorganisms have a long history of providing economically valuable products and services, the enormous success of the polymerase chain reaction (PCR) technique has demonstrated the importance of frequently overlooked components of biodiversity, like thermophilic bacteria, in a tangible way.

A bacterium, *Thermus aquaticus,* was discovered in 1965 from a hot spring in Yellowstone National Park by Thomas Brock. He described the unusual microorganism thriving at 82°C and placed a sample of it in the American Type Culture Collection (ATCC). Years later, when developing the PCR technique in the 1980s, scientists at Cetus Corporation in the United States needed a polymerase enzyme that could withstand very high temperatures. They found such an enzyme, Taq polymerase, from examining the ATCC collection of *Thermus aquaticus.* Cetus patented Taq polymerase as part of the PCR technique and eventually sold the rights to PCR in 1991 for U.S.$300 million.

The application of Taq polymerase in PCR has made millions of dollars for the companies that have controlled its patent (Potera, 1994). However, the real economic value of microbial diversity, which contributed to the development of PCR, is probably incalulable—given the progress this technique has enabled in fields such as medicine and agriculture.

CONCLUSION

The development of nucleic acid techniques has opened the door to discovering a tremendous diversity of

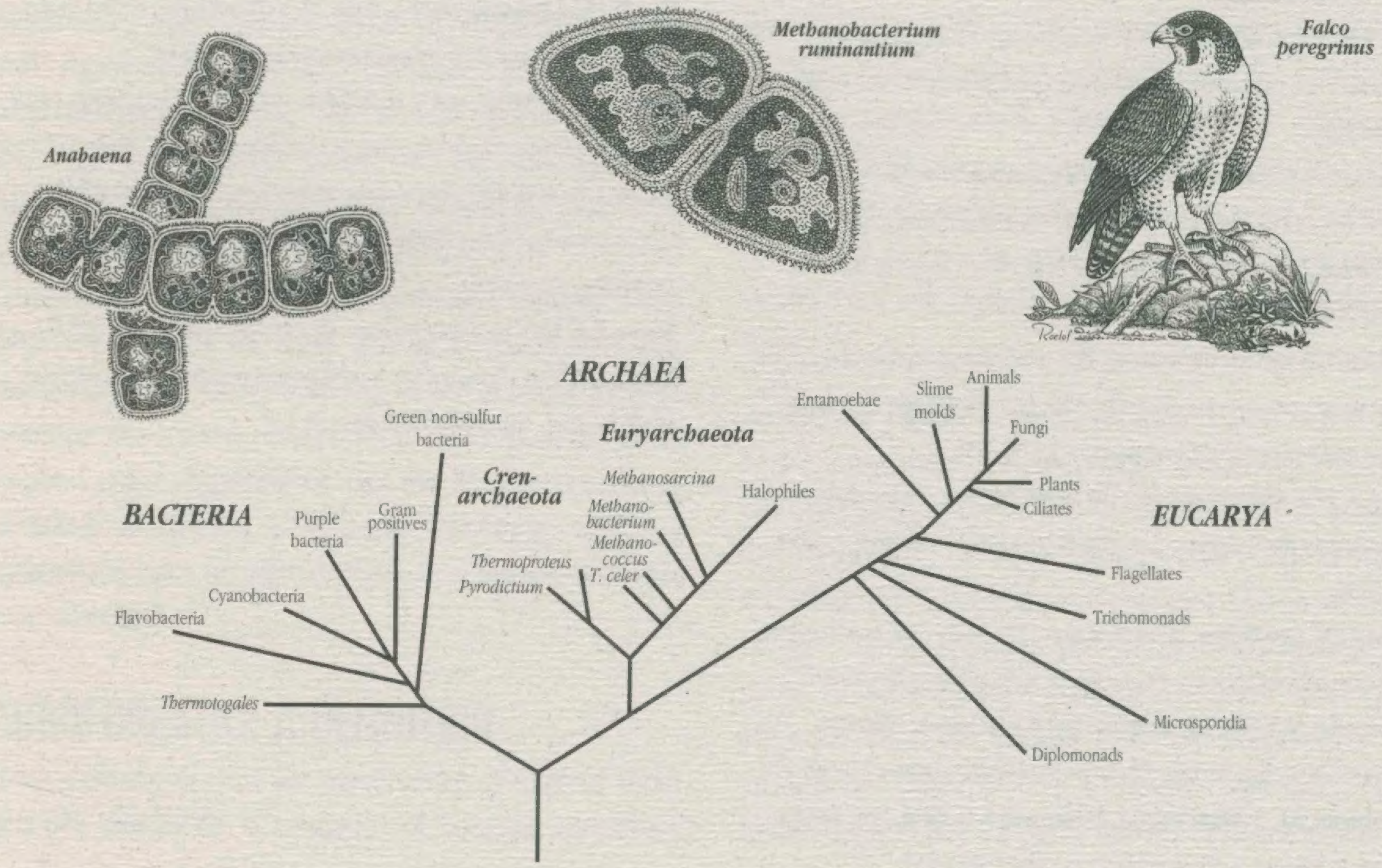
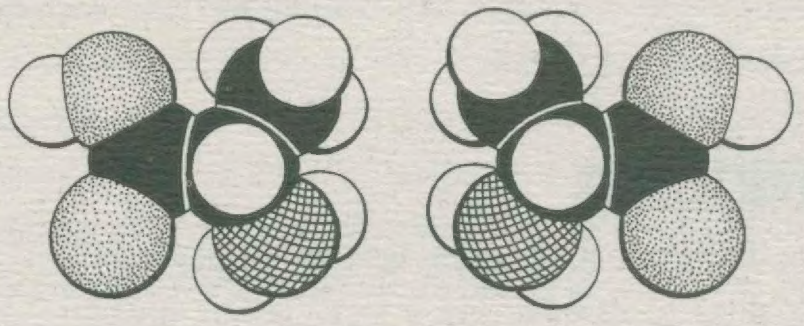


Figure 1
Nucleic acid techniques have revealed new evolutionary relationships and divided the living world into three distinct domains: *Bacteria, Archaea,* and *Eucarya,* which are based upon nucleotide sequences of ribosomal RNA molecules. (Figure after Carl Woese.)

microorganisms. It is unfortunate that the application of these techniques is just beginning as we are facing a precipitous loss of biodiversity around the world. The loss of microbial diversity could be a tremendous blow to the developing biotechnology industry and could have considerable adverse implications for sustaining ecological processes and ecosystems. It has been argued by Bull *et al.* (1992) that the loss of biodiversity should be as ominous for microbiologists and biotechnologists as it is for conservationists.

While few papers, books, and meetings on issues related to biodiversity have addressed microbial diversity to any significant degree, this is starting to change. *Microbial Diversity 21* is a draft action statement emanating from an International Union of Microbiological Societies workshop held in Amsterdam in September 1991 (Hawksworth and Colwell, 1992). It seeks to establish a "Decade of Microbial Diversity" and provide guidance for conservation and research efforts relating to microbial diversity in the 21st century. These actions will be necessary for recognizing the importance of microorganisms in biodiversity issues in the future.



Alanine, $C_2H_7O_2N$ is one of the 20 amino acids used as building blocks for such enzymes as Taq polymerase. Only L-alanine, the molecule on the left, is produced in nature. D-alanine, on the right, is a synthetic molecule.

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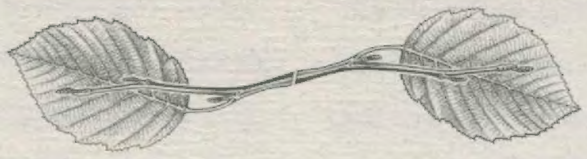

Agroforestry: We owe it to our children

Agroforestry is one of the approaches to a more ecologically oriented agriculture. Benefits can include reduced need for nitrogen fertilizer, reduced wind erosion, and provision of shade for crops like coffee. Agroforestry can provide side benefits, too, like fuel, lumber, shade for cattle, and snow fences. Trees can play a significant role in farms of the future. [D.E.M.]

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There is a lot of talk about sustainability in agriculture and the need to apply more environmentally sound farming practices on our decreasing land base. Agroforestry offers our farmers an opportunity to do just that. Agroforestry is a land management system that combines perennial trees with annual agricultural crops for a more sustainable production method. The U.S. Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS), formerly the Soil Conservation Service (SCS), works under the premise that what we do now on Earth should be done with our children in mind. Conservation is aimed at maintaining or bettering our natural resources for future generations to use and enjoy. Agroforestry uses the lifespan of trees to introduce an element of long-term stability to what has traditionally been an annual production system. But what is agroforestry?

AGROFORESTRY: A DEFINITION

Many definitions exist for agroforestry, but all of them generally discuss the combination of trees and agriculture in time and space. For example, agroforestry is the combination of forestry with agriculture or pasture in a land management system that maximizes the combined long-term yield of desired products. Or to say it another way, agroforestry is the intentional growing of trees in combination with crops and/or forage. These definitions leave a lot of flexibility on how to organize the system on the ground and to decide what products will be produced.

For example, picture a typical agricultural system—a farm with crop fields, pastures, and a homestead. On the crop field, corn and wheat are produced in rotation. The pastures produce forage for a herd of cows. The homestead consists of the barn, corrals, equipment storage, and the farmhouse.

Now picture a typical agroforestry system. Around the corn field, there is a three-row windbreak of trees. The windbreak protects the field from wind erosion in the spring, increases the relative humidity over the field for better crop growth in the summer, reduces the chances of crop blow-down in the fall, and for better soil moisture replenishment, it keeps snow from blowing off the field in the winter. In addition, the farmer is keeping the trees in the centre row of the windbreak pruned so that when retirement comes, a harvest of high quality veneer logs will contribute significantly to the retirement fund.

Around the pasture, a dense planting of pine and fir trees help protect the calves from frigid winds that can cause high mortality in the fragile young animals. In addition, the trees protect the cows from the cold winds of winter, reducing the feed requirements needed to maintain weight. In the summer, the shade helps reduce heat stress, thus increasing weight gains. About seven years after planting, the farmer harvests every other tree around the pasture for a Christmas tree sale. These monies help to pay for badly needed farm equipment.

Jana M. Johnston is a Soil Conservationist with the NRCS in Provo, Utah. She provides technical assistance to landowners in planning resource conservation practices for a wide variety of situations. Her Master's degree is in Forest Biology from Purdue University, and her thesis was titled "An Expert System for Agroforestry Tree Selection in Indiana." Her Bachelor's degree is in Forest Management emphasizing silviculture from the University of Washington, Seattle. This article is reproduced, courtesy of author and the editor, from Volume 16, Number 2 of ***Women in Natural Resources.***

Dense plantings of trees around the north and west sides of the homestead protect it from drifting snow in the winter. Along the south, fruit and nut trees help shade the house from the summer sun while producing delicious products for the kitchen. The east side is devoted to attracting and feeding wildlife year round with various tree and shrub plantings.

Windbreaks, however, are not the only planting arrangements applicable. Some examples of other system designs include:

- Perennial filter strips along streams to filter agricultural chemicals and nutrients or animal wastes;
- Grazing under an orchard to reduce grass habitat for fruit pests;
- Random trees in a pasture to provide shade from hot summer sun;
- Nursery stock planted between every six rows of corn, which is called alley cropping, and can include combinations of many species for a wide variety of products;
- Living snow fences to reduce snow drifts on roads using trees and shrubs instead of traditional wood or metal fencing;
- Wildlife plantings along fence rows and in odd shaped areas of fields.

Bio-engineering and biomass energy production are a couple of other systems that use "working" trees. Bio-engineering is the replacement of typical structural engineering with the roots of living vegetation. For example, instead of building walls or concrete embankments, steep hillsides can be stabilized and protected from erosion by establishing trees, shrubs, and grass. The trees and shrubs are planted in a terrace pattern across the hill allowing their roots to bind the soil together. The vegetation also slows down water movement and increases infiltration into the soil.

Another example is to use trees to reduce irrigation tail water, which often contains toxic salts and minerals. The tail water is applied to tree plantations that evapotranspirate a portion of the excess water, thus reducing the amount needing treatment before its release into natural waters. This method, using eucalyptus, is being practised in the San Joaquin Valley in California to help protect the Kesterson Wildlife Refuge. In addition, the ground water level is being reduced (where needed) by planting trees for evapotranspiration.

A similar system filters nutrient-rich water from animal waste lagoons and from commercial fish production ponds. First, the solids are allowed to settle in the lagoon and then, the water is spread over areas of perennial vegetation. Often a shallow area in the pond supports cattails, reeds, and rushes as an initial filter. Then the water is spread out over grasses and often willows. Finally, trees utilize the remaining water and nutrients. Trees surrounding the fish pond also provide shade and produce organic matter for fish production.

In more humid areas, trees are planted on closed landfills to evapotranspirate water from the top soil. This allows winter rains to refill a soil "reservoir" before moving down into the garbage. Because the water moves more gradually through the soil, a possible leaching problem into the ground water is prevented.

Biomass energy production is currently in a "Catch 22" situation. Fast-growing trees, like poplars and alders, offer an opportunity for biomass production on marginal farm lands. The technology exists to utilize this biomass in energy production, but energy companies are hesitant to locate in areas until a guaranteed supply of biomass exists. Landowners are hesitant to convert to biomass plantations until a guaranteed market exists. Biomass plantations are primarily associated with pulp production for paper manufacturing in today's limited market.

SOLUTIONS TO U.S. AGRICULTURAL PROBLEMS

Some of the concerns about modern agriculture can be directly addressed by implementing agroforestry systems. Historically, U.S. agriculture was dominated by small family farms with each farm producing a variety of products for local markets. As more powerful machinery became dominant, larger and larger farms developed in order to take advantage of the economies of scale inherent in these machines. This led to large fields of one crop over large areas of the landscape—in other words, monoculture. Monoculture creates many problems because of the lack of diversity in both genetics and species. This lack of diversity then leads to increased pests and diseases, increased chemical use, soil erosion, instability of income for the farmer, and detoriating water and air quality.

Increased Pests and Diseases; Increased Chemical Use

Within a monoculture system, there is a limited amount of genetic diversity because usually a farmer grows only one brand of a high-yielding crop. This is coupled with a limited number of brands grown by all farmers. The resulting monoculture creates the possibility of a disease or insect sweeping through an area and destroying all of that year's crop. However, if the landscape was broken up with windbreaks, permanent field borders, and filter strips, natural barriers to the spread of harmful agents would be created.

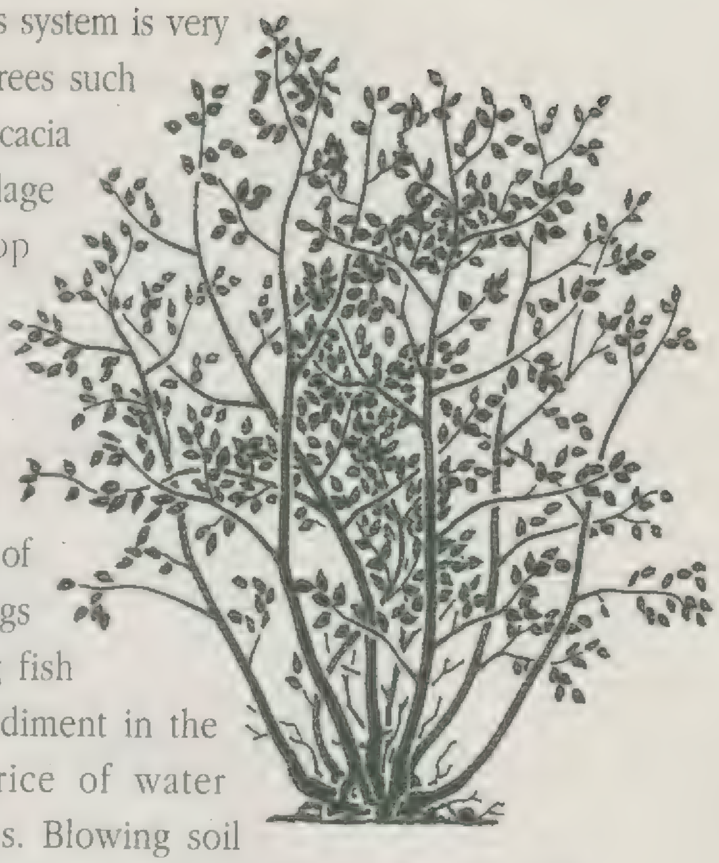
In a monocultural system, agriculture becomes more and more dependent on chemicals to achieve high yields. Because insects can rapidly mutate to adjust to a changing environment, many more powerful and different insecticides are needed to keep up with the mutations. This is expensive for the farmer as well as being detrimental to beneficial insects. While crop rotation reduces some types of insect infestation, other insects are windborne and can travel significant distances to other crop fields. Since the insects are primarily dependent on wind to carry them, windbreaks around fields will help to intercept the insects and drop them on the field in the lee of the windbreak. This creates an opportunity for integrated pest management (IPM) since the farmers will now be able to predict where the insects will first hit their fields and thus, concentrate control efforts within the windshadow of the trees. This reduces the amount of chemicals used and the area needing treatment. A few insects may survive, but their movement across the field and their economic impact will be greatly reduced.

Chemical fertilizers have greatly improved the yield potential of agricultural systems. However, there is a reduction in soil organic-matter and soil structure due to a decrease in organic fertilizer (manure) application. The organic matter is important for holding soil particles together to create soil structure. Soil structure, in turn, creates porosity that allows for better water infiltration and aeration of the root zone. The organic matter also helps to hold fertilizers within the root zone and increases biological activity in the soil from both nitrogen-cycling bacteria and soil-mixing earthworms. While one windbreak or field border will not supply enough leaf material to have a significant impact on the organic matter of large fields, a more intensive agroforestry system, such as alley cropping, could help stabilize the organic matter. This system is very effective when nitrogen-fixing trees such as black locust, red alder, or acacia are combined with reduced tillage methods that help retain crop residues on the soil surface.

Water and Wind Erosion

Soil erosion from both wind and water causes tremendous damage to the natural resources of the country. Displaced soil clogs our streams and lakes ruining fish and other aquatic habitats. Sediment in the water also increases the price of water treatment for drinking supplies. Blowing soil reduces air quality and "sandblasts" delicate crops. The movement of soil by erosion generally reduces the productivity of the contributing fields since that soil is moved to areas not in crop production. Overall in the U.S., soil erosion dumps nearly 58 million metric tonnes of soil per year into the oceans.

With the implementation of agroforestry systems, the perennial nature of the woody materials will help protect the soil from erosive winds and will help filter out sediment from overland flow water before it reaches the streams. In hilly country, farmers are building expensive terraces to help reduce water erosion. These terraces can be built by planting trees and shrubs along the contour and allowing the soil to back up against the vegetation.



Alnus rugosa
If nitrogen-fixing trees, such as the red alder, are used for alley cropping, they can effectively stabilize the organic matter of a field.

Instability of Farmers' Incomes and Employment

Recent reports about the vagaries of the commodities markets gives a good indication of the fluctuating nature of agricultural prices. In a bad year, crop failures abound and the commodity's price is very high for the few farmers able to produce a crop. In good years, the glut of product on the market drives prices down. One year of either situation rarely causes extreme hardship for the farmer, but several years in a row can put a significant number of farmers out of business.

By introducing an alternative tree crop into the farming operation, periodic bad times can be leveled out by marketing the alternative crop. This crop is often a lumber product but can include fruit, nuts, decorative boughs, medicinal chemicals, or forage. For farms based on animal production, tree crops can help replace part of the forage requirement for the animals during drought years when pastures are unproductive. For example, the honeylocust produces very nutritious pods that are highly palatable to cattle.

There is an increasing problem finding and keeping quality farmhands due to the seasonal nature of the job. With agroforestry systems, much of the tree management, such as pruning for black walnut veneer production, can be done in the winter months. This creates a steady employment opportunity and increases the likelihood of keeping employees year round.

Detoriating Water and Air Quality

Water quality has been an environmental concern for many years. The leaching of agricultural chemicals (both pesticides and fertilizers) into our aquifers, streams, and lakes causes severe ecosystem degradation. By incorporating deep rooting trees into the agricultural system, many chemicals can be intercepted below the crop root zones and used before reaching our critical water resources. The increased organic matter in the soil from the tree's roots helps hold pesticides in the biologically active portion of the soil until they are degraded. Fertilizers are picked up by the tree roots and help improve growth while chemicals are kept from polluting the water sources.

Global warming and decay of the ozone layer are broad-based environmental concerns. The planting of trees can help fix a significant amount of carbon dioxide while releasing oxygen. In urban settings, trees help cleanse the air of pollutants that otherwise would rise into the atmosphere. Black walnut, common hackberry, red maple, and white fir are just a few of the species tolerant to air pollution. In all cases, trees benefit humans by improving the aesthetic conditions of the area, and many would credit trees with improving quality of life.

CURRENT STATUS OF WORLD AGROFORESTERY IMPLEMENTATION

Worldwide, agroforestry is not new. On the continents of Africa, India, Asia, and South America, as well as Central America, agroforestry has been researched and applied extensively. Indeed, native peoples in the tropics practised agroforestry before it ever had a title. For example, houses are often surrounded by "homegardens," which consist of several canopy layers and an understory of vegetables that provide a variety of food stuffs for the household. In areas with steep slopes, natural terraces are developed by planting and maintaining grass, shrubs, and trees on contours across the fields. Soil is then held by this vegetation creating a more level farming surface. Living fences, consisting of closely spaced, rapidly growing trees, protect livestock and provide fuel wood for villages. The trees are coppiced (periodically cut at a height of about 1.2 metres) for the fuel wood, and then the stem is left to resprout. The natural fence is maintained and a new fuel wood crop is started.

In addition to the previously detailed systems and those mentioned above, there are many more systems that meet site-specific needs throughout the world. However, many of these systems are designed for the humid tropics or hot, arid regions. In contrast, temperate zone research is relatively young.

In this area, China is one of the leaders. They have used trees to repair the damage caused by centuries of food production for a large population. Systems include windbreaks, terraces, and sand dune stabilization. Australia and New Zealand have also invested in extended research in temperate zone agroforestry by emphasizing high intensity production methods and pastoral systems. Many of their tree products are high quality veneer logs and other fine lumber.

NRCS'S CONTRIBUTIONS TO AGROFORESTRY PRACTICES IN THE UNITED STATES

In the United States, research under the name of agroforestry has just begun. However, in practice though not in name, the SCS (now NRCS) has worked extensively in the agroforestry field since its inception in the 1930s. As a result of the Dust Bowl years, the NRCS is the leader in windbreak technology, and in addition, it advocates the use of riparian filter strips, vegetative streambank stabilization, and hedgerow plantings. These practices have been considered part of a resource management system, but never labeled as agroforestry systems. In addition, these practices are rarely designed to produce alternative crops from the perennial vegetation.

Efforts are currently underway in the NRCS to expand our knowledge and implementation of agroforestry systems. The NRCS's move toward ecosystem-based planning lends itself to the inclusion of agroforestry systems. In August 1994, the NRCS and the U.S. Forest Service sponsored the Agroforestry and Sustainable Systems Symposium Worksession held in Fort Collins, Colorado. Participants discussed ways of educating NRCS personnel and forming partnerships with other entities in the hopes of increasing agroforestry research and implementation.

Today NRCS can have an immediate impact on agroforestry implementation in two areas. As in the past, the first area is in windbreaks. Historically, windbreaks are designed to be essentially static. They are planted, maintained, and renovated—or removed. Under an agroforestry system, they would be planted with species that yielded crops, such as annual fruit or nut crops and longer term lumber crops. The windbreak would be "rotated" as the lumber crops are harvested by planting additional rows. For example, the initial windbreak planting would be three rows: one row of slow growing evergreen (i.e. Douglas-fir, blue spruce, eastern red cedar), one row of high quality veneer wood (i.e. black walnut, pine, ash), and one row of fruit producing species (i.e. elderberry, apple, cherry). When the veneer wood is 10 years old, an additional row of veneer wood with is planted. The original row of veneer wood is harvested at year 20 and another row of veneer wood is planted. This sets up a 10-year rotation of high-value lumber with an annual yield of fruit while protecting the annual grain crop in the field.

The second area of immediate impact deals with the Conservation Reserve Program (CRP). This erosion control program takes land out of crop production and plants it to perennial vegetation, either grass or trees. In areas with sufficient rainfall, many of these CRP hectares have been planted to trees, and at the end of the contract, these trees will be 10 to 15 years old. In many areas, the trees are about a third of the way through a rotation for lumber. Much of the establishment cost has been paid for by CRP and it is a matter of covering the land rent through the rest of the rotation.

With the increased need for private grazing land due to changes in the rules for grazing on federal land, landowners have the incentive to implement an agroforestry system. The trees are large enough that the cattle or sheep are unlikely to damage them, provided the area is managed for proper grazing use. The grazing fee would depend on the quality and quantity of the forage, but would likely cover the expense of management. In addition, fees can be charged for hunting, camping, fishing, and skiing permits. At the end of the rotation, the trees can be harvested for high quality lumber.

CONCLUSION

As partnerships or coalitions increase and demonstration projects are developed, the benefits of agroforestry will be more widely recognized. Beyond the need to address certain natural resource concerns, the American people are clamouring for sustainable lifestyles that include inexpensive food, clean water and air, and nice places to live. When included in an ecosystem-based land management plan, agroforestry systems can help us retain these necessities.

There is no better time than now to plan sustainable urban systems. Increasing urban expansion forces farmers to produce more food on less ground or on marginal ground in an increasingly difficult economic environment. Agroforestry offers some solutions to the problems, but there must be an aggressive push for implementation now. Our children are not getting any younger.

Within an ecoystem-based land management plan, agroforestry can help people live sustainable lives that include inexpensive food, clean water, and nice places to live.

How many trees make a forest? Brazilian rainforest research

The fate of humanity and of tropical and temperate forests are closely tied together. The Brazilian project on forest fragments offers a model of what we should be doing in temperate forests. And it provides critical information for those making decisions on the way rainforests should be managed. [D.E.M.]

For more information, contact:
Outreach Coordinator
Biodiversity Programs
Smithsonian Institution, NHB W314, MRC 180
Washington, DC 20560
email: mnhbd007@sivm.si.edu

INTRODUCTION

The Biological Dynamics of Forest Fragments Project (BDFFP) of the Instituto Nacional de Pesquisas da Amazonia (INPA) and the Smithsonian Institution began in 1979. Based at 11 forest fragments near Manaus, Brazil, the project's central focus is on the effects of fragmentation on tropical rainforest habitat that was continuous until recently. Augmenting these studies are important investigations using the study sites to address questions relating to the biology of extinction, forest edge effects, the processes of forest regeneration, and fragmentation effects on the genetic structure of tropical species.

Complementing this research is an intensive program of graduate education and outreach with Brazilian and international decision-makers. The project's goal is to provide research results to those responsible for the management of rainforest reserves, especially in areas of deforestation, and to foster management schemes that maintain the highest diversity of species possible.

BACKGROUND

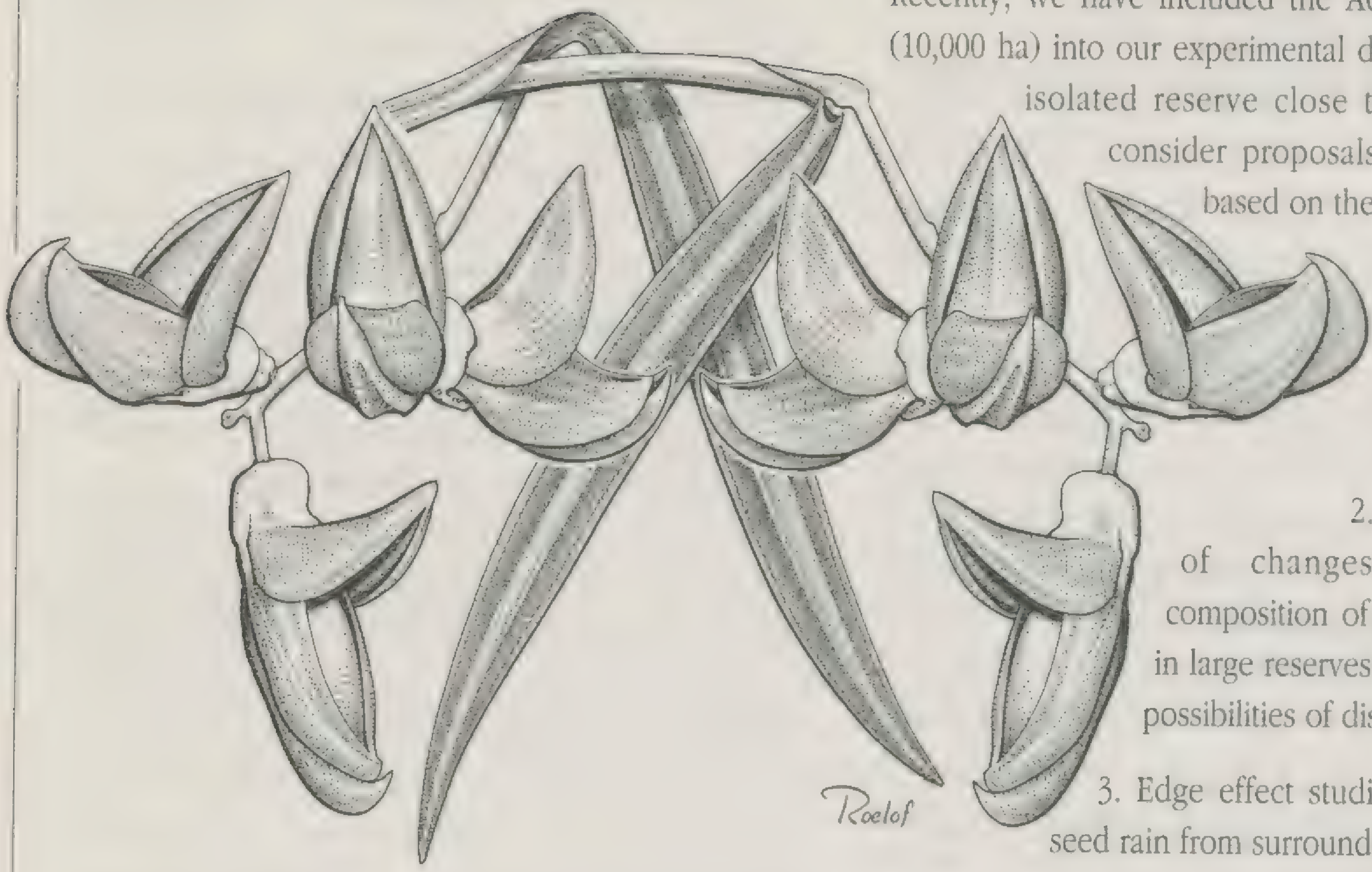
The principal goal of the BDFFP is to determine the effects of forest fragmentation through continuous studies of forested tracts before and after fragmentation. Additionally, insights into the functioning of the intact tropical rainforest ecosystem may be gained by comparing perturbed forest with undisturbed control areas. The process of forest fragmentation, in this case caused by cattle ranchers clearing new pastures, creates extensive forest edge ecotones and large areas of clear-cut pastures.

Results to date show that:

1. Burning of surrounding felled trees results in short-term temperature and humidity effects, which in combination with smoke, affects at least the perimeter of the forest isolates and results in leaf-fall from the forest trees;
2. There are long-term micro-climatic changes of the understory of the forest remnant edges, which entirely penetrate small forest remnants;
3. The species composition in forest isolates changes in ways that were not entirely anticipated, including in some cases, an initial increase in population density of animals that previously lived in the newly cleared areas.

Results to date have also indicated some general consequences of forest fragmentation, but much more study is needed to understand the processes that result in the observed patterns.

While we are maintaining the isolation of our reserves, many of the pastures that surround the isolated forest reserves have been abandoned after treatment ranging from simple clear-cutting (with no burn or subsequent pasture implantation) to felling with heavy cattle use, and most intermediate stages in between. This has fortuitously provided an excellent opportunity to study forest regeneration. Studies by BDFFP have shown that



The common Brazilian riverbank Papilionaid legume, *Centrosema*, is one of 400 legume genera and 10,000 separate species in the Amazon.

the regeneration around forest isolates has a strong influence on the community structure of birds and small mammals in forest isolates. New current research initiated in the matrix habitat around the Project reserves include a carbon-flow model in second-growth areas and studies on the role of leaf-cutter ants, insects, and nutrients in the process of regeneration.

Birds, small mammals, butterflies, and amphibians have been extensively studied ecologically in both continuous forest and the isolates. Work on primates carried out early in the Project's history needs follow-up. As well, insects, which represent a large component of the fauna, are under-represented in the bulk of the work performed to date.

STUDY SITES

The continuous forest at the study site which is situated on four different farms (fazendas) located north of Manaus, is relatively undisturbed with large predators such as jaguar *(Panthera onca)*, puma *(Felis concolor)*, and both Harpy *(Harpia harpyja)* and Crested Eagles *(Morphnus guianensis)*.

The original design was to have as many replicates of different-sized fragments as logistically possible. The Forest Fragment Size table (at right) indicates the number and sizes of isolates originally planned, those that are being studied in both a pre- and post-isolation condition, and the number of patches actually isolated at present.

Recently, we have included the Adolfo Ducke Reserve (10,000 ha) into our experimental design. This is a large isolated reserve close to Manaus. We will consider proposals to work in Ducke based on the following criteria:

1. Studies of the effects of fragmentation on large vertebrates;
2. Long-term studies of changes in community composition of mammals and birds in large reserves without corridors or possibilities of dispersal;
3. Edge effect studies in areas without seed rain from surrounding areas;
4. Studies that require constant use of Manaus laboratories.

Because of the importance of experimental manipulation beyond that provided by the isolation of a replicated series of forest reserves, several reserves (three-10 ha and one-1 ha) have been identified as "experimental." This is not a carte blanche authorization to remove or introduce organisms into the reserves, but rather implies that such proposals will be entertained and evaluated according to their potential effects on research in progress in the reserves.

FOREST FRAGMENTS SIZE

ha.	**1**	**10**	**100**	**200**	**1,000**	**10,000**	**(Control)**
Number of Fragments	8	9	5	1	2	1	1
Currently under study	8	8	5	1	2	1	1
Currently isolated	5	4	2	1	0	1	0

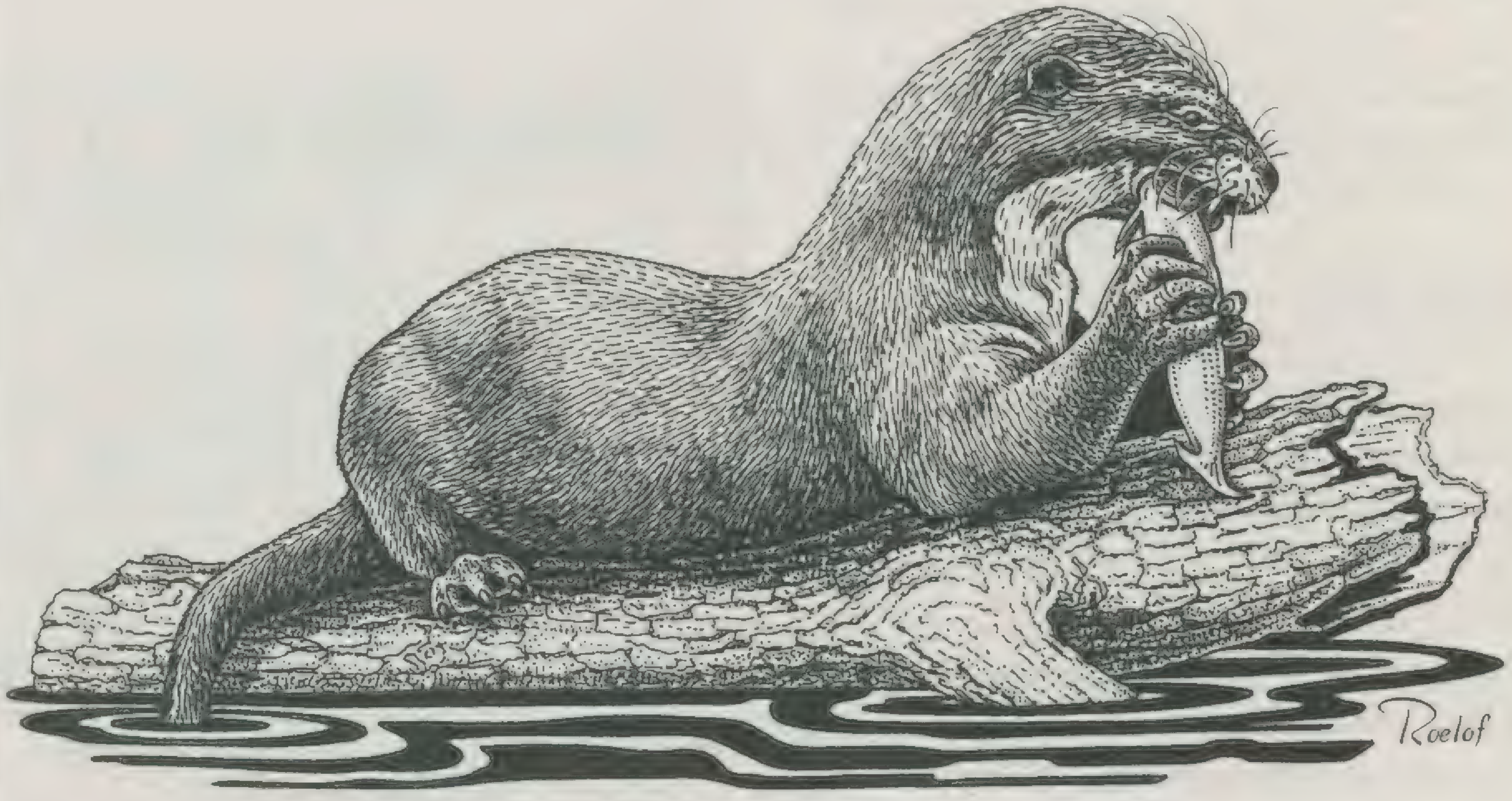
SAMPLING PROCEDURES, DATA ANALYSIS, AND SPECIMEN DEPOSITION

For some organisms the smallest patches (1 and 10 ha) can be completely inventoried, while the largest patches can only be sampled. Accordingly, while inventory methods obviously will vary with the group of plants or animals under study, it is important for each sub-project to standardize sampling procedures for all patches to produce comparable data. It will be important to solve some of the problems so that proper comparisons can be made between the small and large patches. One general approach the Project has used is to gather data that allows construction of species-area curves for different organisms, and in the process to test the effect of sample size on species richness, which ultimately might provide a quick and easy measure of the success with which a patch is maintaining its pre-isolation conditions. Nested plots within the larger reserves provide interesting comparisons with similar-sized fragments and provide data for species-area curves. All inventory based studies are expected to contribute to the generation of species-area curves.

While each investigator is scientifically and editorially independent, whenever possible, data should be collected so as to be adaptable to a common computer format and compatible with other studies in progress. Researchers will be encouraged to participate in "inter-sub-project" analyses and publications.

Each scientist is subject to the research regulations of Brazil and, in particular, of INPA. This includes regulations for collecting and specimen deposit. All material collected by Project participants belongs to INPA. Donations to other institutions may be arranged, but at least half of the specimens and all holotypes must remain in Brazil. Arrangements regarding the deposition of holotypes in Brazil can be negotiated individually. Requests for authorization to collect in the study plots and their immediate vicinity will be reviewed on a case by case basis by the Management Committee. Authorization generally will be granted only when field identification is difficult, making collections necessary. For obvious reasons, projects whose main purpose is collecting will not be permitted in the immediate vicinity of the reserves. However, researchers intent on extensive collecting may take advantage of the Project's infrastructure and work with one of INPA's curators.

Those interested in working in the Brazilian rainforest in conjunction with the BDFFP are encouraged to look for further information about submitting proposals on the opposite page or contact the Outreach Coordinator at the address listed at the beginning of the article.



The Giant Otter, *Pteronura brasiliensis*, feeds primarily on fishes and crustaceans. Two of these sleek, adroit carnivores may eat three tons of fish in a year's time. They inhabit shallow tributaries of the Amazon, where fishermen consider them competitors—with sad consequences. Both the fur and the meat of this otter are used by indigenous peoples.

DETAILS ON SUBMITTING PROPOSALS TO BDFFP

Pertinent Topics for Proposals

Proposals for participation should address one of the following topics:

1. Biotic and abiotic effects of forest fragmentation;
2. Biological mechanisms that result in extinction;
3. Process of forest regeneration;
4. Ecological processes affected by fragmentation; and
5. Fragmentation effects on the genetic structure of tropical species.

Types of Proposals Accepted

Categories of proposals include:

1. Requests for use of facilities and study area without funding;
2. Requests for partial funding; and
3. Requests for full funding.

Deadline for Submissions and Timing of Approval

Funding from BDFFP includes logistics support (transport, food, technical help), supplies, and equipment. Proposals accompanied by a cover letter and current CVs should be sent no later than 15 May 1996 to: Dr. Claude Gascon/Scientific Coordinator, PDBFF/INPA Ecologia/C.P. 478/69011-970 Manaus AM/BRAZIL/Tel: (55-92) 642-1148/Fax: (55-92) 642-2050

Proposals can be submitted after the deadline and will be evaluated. However, chances of receiving funding are much better during the yearly review period.

The Director will distribute the proposals for review. All proposals will be evaluated by BDFFP's Scientific Advisory Committee and a decision will be made by the Management Committee in September. Approved projects can start field work in October 1996.

Qualifications Needed

Principal Investigators for each proposal must have a Ph.D. or equivalent degree. Collaborators may include graduate students or other qualified researchers. In the case of graduate students collaborators, a letter from the P.I. (supervisor) detailing the student's progress must accompany the proposal.

Foreign (non-Brazilian) researchers should plan to set up a collaborative project with a Brazilian counterpart. This implies involving Brazilian graduate students, if necessary. The Management Committee will assist in establishing collaborative efforts with researchers at INPA.

Investigators should submit six copies of each proposal and CV. Write to obtain copies of the format before submitting. Proposals not adhering to the format will not be reviewed.

Funding

The Smithsonian Institution relies on contributions from corporations, private funding organizations, individual donors, and modest federal support to provide the necessary funding. The first funding priority goes towards maintaining the infrastructure needed for researchers to do their studies. Beyond that, funds will be used to support ongoing and new projects with preference given to support work by Brazilian researchers and graduate students. Given our current financial outlook, support to non-Brazilian researchers and students is very limited. Proposals from such sources are expected to include substantial outside funding. All researchers wishing to work on the Project or use its facilities must submit proposals even if no direct financial support is needed from BDFFP funds.

FACILITIES AND EQUIPMENT

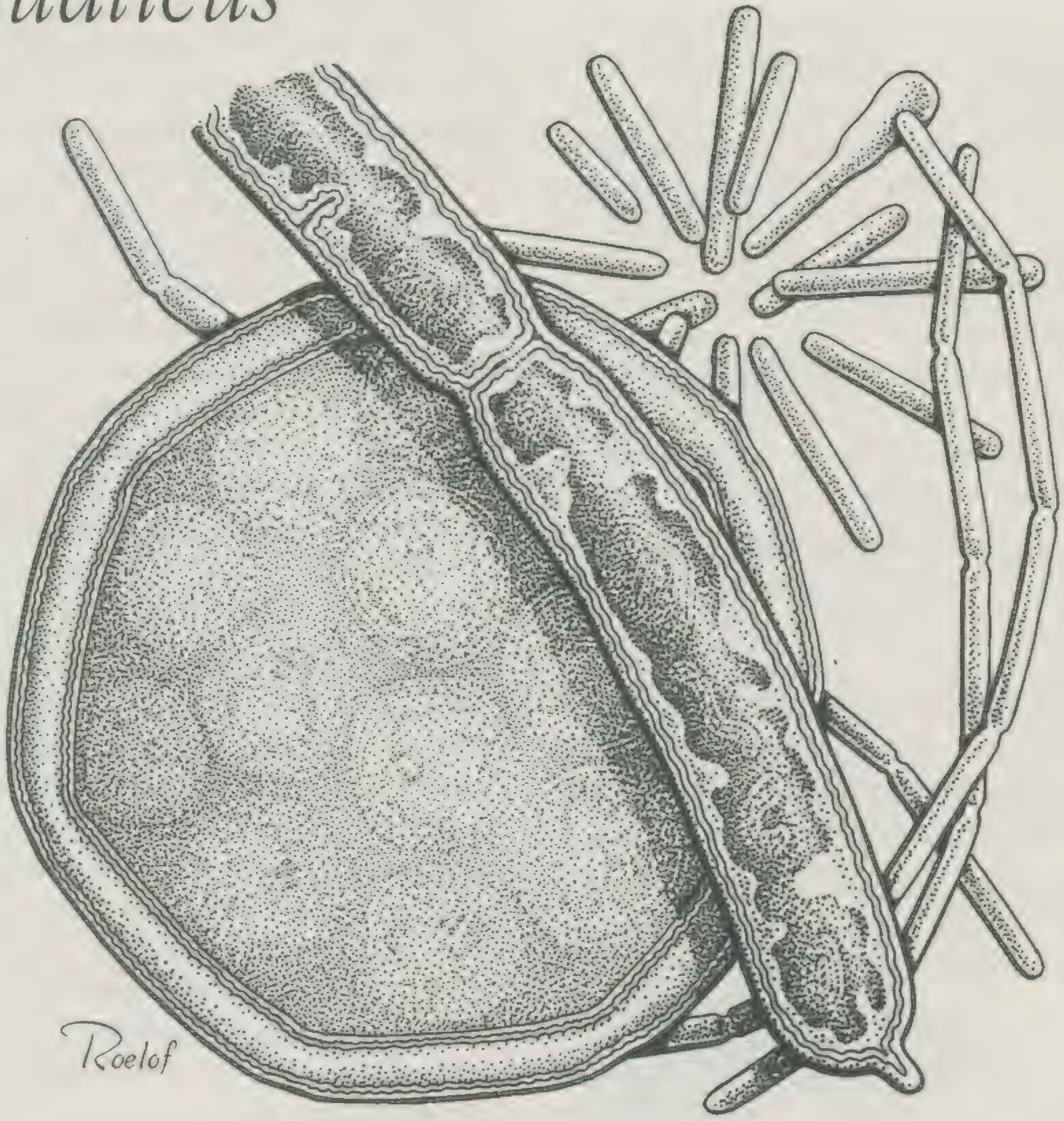
BDFFP operates from a central office in Manaus, which handles administration and logistics support of the project. The main office area includes a reading-study room, a computer room (equipped with IBM and Macintosh computers), a herbarium, and a small laboratory. A fleet of 4-wheel drive vehicles transport project personnel and researchers between Manaus and any of the eight base-camps set up 80 km north of the city. Camps are rustic but comfortable, and include a dormitory, a laboratory hut, and a separate kitchen area. Our control camp has a generator providing 110V current.

SCHEDULE OF FEES (EFFECTIVE 05/94)

Room Rent (in Manaus)	
Senior researchers	$100 (monthly)
Students/Assistants	$ 50 (monthly)

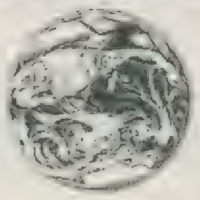
Food and transportation (at field sites)	
Researchers and students	$ 20 (daily)
Day visitors	$ 30 (daily)
Journalists/Filmmakers	$ 50 (daily)
Technical assistants	$500 (monthly)

Thermus aquaticus



Three forms of the bacterium are shown here. The first, in the foreground, is an entire rod joined to a partial rod. The second is a spherical morph or form. The third, in the background and at a smaller magnification, is a three-dimensional rosette structure.

Thermus aquaticus is an aerobic bacterium found in hot springs, first described from Yellowstone National Park (U.S.A) in 1965. At the time, its most notable feature was that its optimum temperature for growth lay between 70 and 75°C. This little known and otherwise unremarkable organism was soon to revolutionize molecular studies. Its unique biochemistry was to become integral to the polymerase chain reaction (PCR) method, which was developed to replicate a DNA sequence. When first developed, the DNA polymerase (an enzyme used to split up the DNA molecule in order to analyse base sequences, a key step for all DNA work) that scientists used denatured or broke down at high temperatures (60 to 90°C). However, the DNA polymerase from *Thermus aquaticus* (Taq polymerase) was found to be heat stable and contributed to an automated, relatively easy means of reproducing even a small segment of DNA a million- or billion-fold. This discovery, which led to a major refinement of PCR and was subsequently patented, earned Cetus Corporation of California an initial income of over $300 million. The applications of PCR include the Human Genome Project, molecular evolution studies in systematics, diagnosis of genetic diseases, and forensics—most notably in a recent sensational murder trial in the U.S.



Consequences of transgressing human laws and nature's laws

Don E. McAllister
Canadian Centre for Biodiversity
Canadian Museum of Nature
P.O. Box 3443, Station D
Ottawa, Ontario K1P 6P4

We humans have created environmental laws since recorded history began. And since the beginning, we have transgressed the very laws we have created. We either break our laws or weaken them, despite the fact that it is a good idea to adhere to laws, or so said St. Thomas More. Adhering to laws protects us from anarchy.

The consequences of disobeying human environmental laws, such as is done by polluters and poachers, depend on whether you get caught, how good a lawyer you have, the degree of corruption in the political-legal system, and the penalties determined by the articles of law and the judge. There may be no penalties, weak penalties, or stringent penalties. The better the enforcement and the more just the legal system, the more likely that a wrong-doer will receive appropriate punishment.

The consequences of weakening good environmental laws and programs or repealing them, as the Canadian Parliament and the U.S. Congress are now doing, varies. It all depends on the responsibility of the press, the perceptions of the opposition, the wisdom of the electorate, and the length of their memories. The consequences of transgressing human laws is, therefore, probabilistic, a roulette in which the wheel may or may not stop with the indicator pointing at the pollutor, poacher, legislator or political party.

In contrast, the consequences of trangressing the laws of nature, framed by thousands or billions of years of evolution, are inevitable. The consequences are not always large. Sometimes, in fact, they are short-term and locally based. But, whether large or small, local or global, short- or long-term, the consequences will come. In this era, because we have a much more rapid impact on nature and on a larger scale than ever before, the consequences may arrive sooner than later.

We should be wary of transgressing nature's laws, which are higher than our own. We should elect legislators to frame and strengthen our educational and legal systems so that nature's laws are never broken. These systems should be designed to quickly trounce those who show no respect for nature. We should understand before we meddle, we should take precautions when we are uncertain. If we do not, we—or our descendents—will surely have to face the inevitable, natural consequences of breaking nature's rules.

Three simple laws of nature are:

1. **Don't throw away the parts (Leopold's Law).** Keep species and ecosystems, even those whose role we don't understand. They may be carrying out significant ecological functions.
2. **Maintain the connections of the web of life; everything is connected to everything else (Seattle's Law).** Sea otters moderate sea urchin populations, which in turn, let kelp forests flourish...insects pollinate flowering plants.... The connections between these life forms are just as important as the parts.
3. **Leave sufficient for the functions (Don's Law).** It is not enough to save samples of the parts and the linkages. The Noah's Ark approach will not save the ecological functions or ecoservices. There must be enough of the species and ecosystems to carry out these functions at local, regional, and planetary levels. Only by preserving enough forests, grasslands, and marine diatom meadows will we keep the oxygen and carbon dioxide levels in balance. See more discussions of ecoservices in Ted Mosquin's paper in *Global biodiversity* 4(3): 2.

We break nature's laws at our peril..and the ecosphere's.

The Canadian Museum of Nature is pleased to provide an open forum for diverse viewpoints even though they may not represent the views of the Museum itself. Comments on these viewpoints are encouraged. Please mail or fax them to the editor (address on page 1).

17 MARCH 1995

U.S. Vice-President Gore on climate change

Governments are a bit like supertankers, hard to get moving and difficult to steer. It is good to see a politician, like Vice-President Al Gore, close to the helm of the ship of state. He is knowledgeable, wise, and has good communication skills—as demonstrated in this speech on climate change given last March. Climate change is one of the major threats both to the ecosphere and to a reasonable quality of life, indeed survival, for humanity. Read what Gore has to say, and then decide on YOUR action plan. [D.E.M.]

Two weeks from now, the issue of global climate change will be discussed by more than 120 different countries in Berlin as they begin the First Conference of the Parties for a Framework Convention on Climate Change. Since it's St. Patrick's Day, I thought I would begin a discussion of this issue by quoting an old Irish politician, Sir Boyle Roche, who once asked in the last century, sarcastically, "Why should we put ourselves out of our way to do anything for posterity? For, what has posterity ever done for us?" That way of thinking would go over really well in this session of Congress!

Posterity is particularly relevant when talking about global climate change, because our actions today will have far-reaching implications for the environment that we leave to future generations. A commitment to posterity requires that we accept and understand this profound change in the nature of the relationship between human civilization and the ecological system of the Earth.

I mentioned a moment ago that, in my view, global climate change is a manifestation of that radical change in the fundamental relationship between civilization and the Earth. There are other manifestations—the rapid destruction of forests, especially tropical rainforests; the unprecedented loss of living species at a rate that has not taken place on this planet since the disappearance of the dinosaurs so many tens of millions of years ago; the poisoning of air and water in many places on the Earth; and the degradation of important ecosystems, from the Aral Sea in Central Asia to the coral reef networks in shallow areas of the world's oceans.

All of these, including global climate change, are manifestations of this change in the relationship between human beings and the environment. This radical change has come about in the lifetimes of people gathered here in this auditorium because of a confluence of three factors. The first is the unprecedented explosion in the numbers of human beings around the world. We're adding the equivalent of one China's-worth of people every ten years. Still, we have begun to address a sensible plan of action to assist nations that wish to stabilize population growth. But the momentum built into the numbers themselves ensures that the rapid growth will continue for quite some time to come.

The second of these three factors is the acceleration of the scientific and technological revolution, which has vastly magnified the ability of the average human being to have an impact on the environment around him or her. To use an analogy, warfare is an ancient habit of human civilization. But the invention of nuclear weapons so completely transformed the consequences of all-out warfare as to require us to go back and think anew about that age-old habit. The Cold War was, in part, a result of that sobering re-examination of what all-out warfare would mean with these incredibly powerful new weapons.

But all of them taken together have transformed the consequences of all-out exploitation of the Earth, just as surely as nuclear weaponry transformed the consequences of all-out warfare. And so we must think anew about the way in which we go about exploiting the land and the sea and the air or the sustenance that we need to survive.

In some ways, the third factor leading to this radical change is the most important. It is a philosophical shift in our way of thinking about the consequences of what we do to the environment, a change which has led too many people to assume that we need not take into account the future effects of our present actions.

All three of these factors together have created a change that we are attempting to come to grips with in sessions like the one in Cairo on population and sustainable development [See *Global biodiversity* 4(4): 16-18 for more on this conference and its relationship to biodiversity]; sessions like the many that led to the Montreal Protocol to limit the introduction of ozone-depleting substances into the stratosphere; and conferences like the one in Berlin two weeks from now, which will address global climate change.

In order to deal with this issue, we have to begin with the facts. And any discussion of the facts must take into account categories upon which there is agreement and categories that are characterized by disagreement. I would like to concentrate on the former rather than the latter, because there is wide-spread agreement about the central facts that characterize this problem.

"In my view, global climate change is a manifestation of a radical change in the fundamental relationship between civilization and the Earth."

The revisionist view notwithstanding, there is a firm domestic and international consensus on the most salient issues:

Number one: We know that greenhouse gases are building up rapidly in the atmosphere. Concentrations of carbon dioxide have increased about 25% since the Industrial Revolution; nitric oxide has gone up by 15%; methane has gone up by more than 100%.

Number two: Scientists also agree that continuing this buildup of greenhouse gases will cause the climate to change. Note that the operative word in that sentence is not "may," but "will." A continued buildup of this kind will cause the climate to change. About that there is no serious disagreement. The scientific community cannot tell us the pace of these changes or the precise pattern they will take, but they are telling us that change is coming.

There is an international consensus that global surface temperatures could increase from an average of -17°C to -13°C over the next century. That is a rate unseen on this planet for at least the last 10,000 years. That is, unseen during the entire history of human civilization! Since the first cities appeared on the Earth, no such change has been seen.

The United States and other areas in high latitudes are projected to warm even more, with increases of up to 12°C. In just the last century, the Earth's temperature has risen by about 0.5°C. The nine warmest years in this century have all occurred since 1980, even though the eruption of Mt. Pinatubo, as predicted at the time, held down temperatures for about three years, until the heavy particulates blocking out a tiny fraction of the sun's radiation fell back out of the atmosphere to Earth.

Already, there is ominous evidence of significant change underway. Alpine glaciers in every part of the world are retreating rapidly. You may have seen the pictures not long ago of the prehistoric traveler whose body was found in a mountain pass in the Alps in Italy. They were walking along, and there he was. Why had no one noticed him there for the last 5,000 years? Because the ice covering him had not melted in 5,000 years. Now, it has melted. In other areas, which have not seen the ice retreat in human experience, the ice is now retreating. There is a decrease in northern hemisphere snow cover; evidence of a decrease in Arctic sea ice. Average precipitation in the lower 48 states has increased in the last century by about 5%. Torrential rains have increased in the summer during agricultural growing seasons.

These are troubling, complex, and challenging issues to confront, but we should not imagine that they are occurring according to a pattern of slow and gradual change. We know that natural systems are replete with thresholds beyond which change can occur suddenly and dramatically. A warmer Earth alters precipitation, soil moisture, and sea level that can then lead to changes in the ideal ranges for crops, forests, and wetlands. Changes in precipitation patterns cause drought in some areas and more rainfall in others. They cause a change in the distribution of microbial populations, and thereby, create vulnerabilities to viruses and bacteria. They also cause a change in the distribution of pests and that of plant and animal life.

Combinations of changes can have dramatic effects—increased rainfall can lead to more floods, which together with higher sea levels, can threaten the existence of some low-lying coastal communities, threaten the existence even of some small island nations and low-lying coastal nations.

We have seen concern expressed by scientists in several parts of the world about the increased frequency of drastic weather events. In our own country, we have seen the effects of a shift in the pattern that we call El Nino, from a pattern that occurs every two to five years to a relatively new pattern during the last decade and a half in which it has had a tendency to become almost constant.

Some members of the business community, whose lines of work make them especially sensitive to these kinds of changes, are also beginning to express concern. Recently, I met with a large number of representatives from the insurance industry and the reinsurance industry. Frank Nutter, President of the Reinsurance Association of America, has warned about a serious risk of bankruptcy within the insurance industry, which can come from, in his words, "significant and perhaps, permanent changes in our climate in this country and in the world."

> ***"...we simply cannot ignore the fact that emissions are rising fastest in developing countries..."***

It's easy to see why insurance companies are concerned. In 1993, the Mississippi flooding caused an estimated [U.S.] $10 billion to $20 billion worth of damage. Hurricane Hugo cost the federal government alone about $1.6 billion. Hurricane Andrew topped $2 billion in federal disaster payments and cost property insurers at least $16 billion. The floods and mud slides in California have caused over $2 billion in damage already this year. [For more on ecological control of flooding, see *Global biodiversity* 3(3): 21-28.]

Will an altered climate pattern lead to an increase in the frequency of severe events of this sort? Should we take action to diminish altering climate patterns? We ignore these changes at our peril. I mentioned that climate change can cause a shift in the distribution of microbial populations. This shift can significantly change the range of infectious diseases, such as malaria and dengue fever.

How should we respond to this kind of threat? The Clinton administration believes that we must guard against potentially devastating effects, even as we deepen our scientific understanding of these issues through an aggressive research program. This approach is, in fact, analogous to an insurance policy and is not just an abstract notion.

Three years ago we joined the international community in signing the historic Framework Convention on Climate Change. It was the beginning of a process to design a kind of insurance policy. It was a treaty that called on all nations to work together in an unprecedented effort to protect the global environment. Specifically, the industrialized countries were urged to take the lead by stabilizing greenhouse gas emissions to 1990 levels by the year 2000.

Soon after taking office, President Clinton went beyond the vague, non-binding language of the treaty, declaring that the United States would meet the goal set out in the treaty. The President's commitment was made to complement his economic objectives. He promised to turn our economy around, and he has delivered. Inflation is down, growth is up, unemployment is down, jobs are up. All told, we are demonstrating that economic and environmental progress can go hand in hand.

No doubt, the powerful economic course set by President Clinton challenges several of the assumptions of the plan. Rather than turning away from this good news, we embrace it. Today I want to reaffirm the President's pledge: The United States is committed to reaching 1990 levels of greenhouse gas emissions by the year 2000. We've developed an ambitious plan aimed at fulfilling the President's commitment. Forty out of forty-seven of these initiatives have received funding and are now underway. Most of these initiatives share at least one common feature—they will mean new, clean American jobs for our future.

For example, we have signed voluntary agreements with the bulk of our utility industry to keep greenhouse gas emissions down. Similar partnerships have been forged with U.S. industry on energy-efficient computers, buildings, and lighting systems. We have pledged $430 million to the Global Environmental Facility for its second phase—the largest contribution of any nation in the world. We have created a new environmental technology initiative, totalling more than $1 billion, to develop and disseminate environmentally superior technology. And, the U.S. has launched the world's first pilot program to assess the feasibility of joint investment projects with other countries aimed at reducing or sequestering emissions of greenhouse gases and promoting sustainable development.

In addition, we have launched a partnership for a new generation of vehicles, also known by some as the Clean Car Initiative. It is a real partnership. All three of the big automakers are participating, along with the national laboratories, relevant federal agencies, and many suppliers of parts, materials, and equipment; also, engineering faculties and students across the country are participating. Together we're tackling a technological challenge, which is as tough, in some ways, as putting a man on the moon. We're going to develop a car with three times the efficiency of today's automobiles with no sacrifice in cost, comfort, or safety.

In the process we hope to discover the best ways to apply new technologies that may, in fact, lead to even greater improvements in efficiency—all in ten years' time. Success will mean less dependence on foreign oil and lower emissions of greenhouse gases. And, of course, in addition to the benefits for the American consumer, the project also holds the promise of an extremely attractive and competitive automobile for world markets at the turn of the century and the thriving U.S. auto industry to produce them.

In our building and construction initiative, our goal is to improve the competitive performance of this $800 billion industry by developing much better construction technologies that lead to less emissions. With the full cooperation of the industry, we're determined to ensure that our buildings, like our industry, are the most productive, efficient, safe, and durable in the entire world. That means cutting delivery time in half with a 50% reduction in cost.

We want to see a 50% reduction in construction work injuries and illnesses while at the same time improving productivity and comfort by 30%. And we're developing detailed plans with the industry to reach these objectives. We want to see 50% less waste and pollution and 50% more durability and flexibility.

We recognize that our plan is ambitious. And we recognize that it requires support from leaders on Capitol Hill. Some of our previous requests were not fully funded, and Congress is now considering taking back previously approved funding. Just as this treaty requires international consensus, our domestic response to it requires a national consensus. We are committed to working with the Congress in a true partnership on behalf of our nation, the world and all of its people.

But it is incumbent upon the new leadership on Capitol Hill to step up to the plate and recognize both the challenges and the opportunities presented by climate change and recognize, too, the need for U.S. leadership.

Fulfilling this responsibility in the future requires acknowledging that our plans and those of our industrialized partners are only the first step. In two weeks, in Berlin, nations will meet to determine what more the international community can do in response to the dramatic scientific evidence that now exists. Once again, this administration will be at the forefront of this global effort.

For almost a year we have said that we do not believe that the current agreement is adequate. It only contains one aim or goal for the year 2000, and this aim only applies to a limited number of countries. We are now in a situation in which the maximum response that is politically feasible throughout the world still falls short of what is really needed to address the problem. All the nations of the world will need to work together to develop guidance on what steps to take beyond the year 2000. So we must negotiate a new aim for the future.

In view of these limitations, and mindful of our responsibility to the future, we are working with other nations to develop a mandate that can be agreed upon in Berlin and can set the course for next steps under the treaty. This will require us all to carefully examine what we each can do to contribute to further reductions in greenhouse gas emissions. Our goal in Berlin, in other words, is to build a foundation and begin momentum.

Just as there are thresholds in the natural climate system, there are thresholds in the political system. When evidence accumulates to the point where enough people are no longer willing to listen to skeptics who have arguments that are not grounded in the facts, then beyond that threshold, the possibilities for significant action improve dramatically. That is why it is important to develop quality research.

We've already begun that process here in the United States, and that will be a part of the process we will follow in the future.

But now is the time to re-launch negotiations and walk more concretely toward the treaty's objective. Now is the time to establish a new negotiating mandate that will allow us to fulfill our responsibilities to future generations—a mandate that ensures we move forward from the important first steps outlined for the pre-2000 period.

We strongly believe that all nations must participate in this effort. Certainly, industrialized countries that have contributed most of the problem can and should take the lead. And we shall. But we simply cannot ignore the fact that emissions are rising fastest in developing countries, which together now account for almost 50% of all greenhouse gas emissions in the world. We know that industrialized countries have special responsibilities, and we fully support the Convention's call for common but differentiated responsibilities. But we very much want the developing nations to join us at the negotiating table, so that together we can define these common but differentiated responsibilities in the post-2000 era. Not so that alone we can do less, but so that together we can do more—through trade, technology cooperation, and a host of strategies that offer benefits for all nations.

PRINCE EDWARD ISLAND, CANADA, 1995

WILL THIS BE PRINCE EDWARD ISLAND, 2095?

The Honourable Sheila Copps, Canadian Minister of the Environment, predicted on a television interview in the spring, "Most of Prince Edward Island will sink under the sea unless the world takes action on global warming," and that "Prince Edward Island will be flooded and reduced to a series of little islands."

We also must do a better job of ensuring that nations are matching rhetoric with reality; that we are accountable for what we say we will do. To date, only a handful of nations have put forward clear substantive proposals that move them toward the emission reductions they have enunciated. We must be clear: Good intentions and high-flying rhetoric will not come close to helping us meet the very significant challenges inherent in reducing emissions. What is needed and expected under the treaty is concrete action.

In the negotiations that will follow the Berlin meeting it is imperative that we establish a menu of measures from which to choose strategies for reaching any new aim set for the post-2000 period. Only an analytic phase as part of the negotiating process can provide us with realizable measures, and the realistic understanding of what our expectations and goals should be for the future. But the measures selected must truly achieve emissions reductions, and nations must be prepared to show actions and results.

Finally, we believe that the mandate for negotiations should be concluded as rapidly as possible. We believe that an aggressive, ambitious approach, looking at short-term and long-term goals—that is, for the years 2010 and 2020—can be concluded by 1997, when the Third Conference of the Parties will be held. We think this date is a fair one, one that reflects our view of the importance and urgency of the climate change problem and also gives us the lead time to develop and begin to take advantage of new technologies.

LOOKING BACK AT BERLIN

The Climate Summit was held in Berlin from 28 March to 7 April 1995 and received much media attention. For those wishing more information on climate change in general and viewpoints on the conference—its achievements and failures—there are a number of places on the Internet worth exploring. A smattering of information is provided below from these sources along with their Internet addresses.

From **"Understanding Climate Change: A Beginner's Guide to the UN Framework Convention."** UNEP/WMO Information Unit on Climate Change (IUCC), December 1994 IUCC, UNEP, Geneva Executive Center, Box 356, 1219 Châtelaine, Switzerland. Internet address: **http://www.unep.ch/iucc/begincon.html** "The Climate Change Convention (United Nations, 1992) focuses on something particularly disturbing: we are changing the way energy from the sun interacts with and escapes from our planet's atmosphere. By doing that, we risk altering the global climate...."

[The document then looks at a series of five problems and how the Convention responds to these issues. (1. Can we handle rapid climate change? 2. Do we ignore the problem—because the consequences are uncertain—or do we do something about it anyway? 3. It's not fair. 4. If the whole world starts "living the good life," can the planet stand the strain? 5. Who has the time, energy, or money to deal with climate change, when we have so many other problems?)]

"The Framework Convention...is aimed at the next century as much as this one. It establishes institutions to support efforts to carry out long-term commitments and to monitor long-term efforts to minimize—and adjust to—climate change. The Conference of the Parties, in which all states that have ratified the treaty are represented, is the Convention's supreme body. It meets for the first time in March 1995 and on a yearly basis thereafter."

From **"Climate Summit Fails to Combat Climate Change,"** Berlin Summit Daily Update, GREENPEACE. Internet address: **http://www.cyberstore.ca/greenpeace/climate/berlin1995/index.html**

"In Berlin, the Climate Summit agreed on what can only be termed a 'soft mandate'—which failed to adopt specific reductions, using words like 'quantified limitation and reduction objectives' with time-frames such as 2005, 2010, and 2020...."

"These definitions are weak....The Governments didn't take up the proposal offered by the 'front line states'—the 36 small island states—for a way out of climate change. They are only willing to include the AOSIS protocol 'for consideration in the process.'"

From **Network Newsletter Articles**—April-July 1995. Internet address: **http://www.ucar.edu/esig/newshp/articles.html** There are a series of 26 articles posted here ranging from Global Warming Update," to "Climate Convention—African Concerns," to "GEF-Funded Climate Change Projects," to "Finnish Climate Change Program," to "China's Response Strategy for Global Climate Change," and so on.

From **"From Berlin to Kyoto?"** *Eco* 10, 7 April 1995. *Eco* is the newsletter of the Climate Action Network (CAN) published at the UN Climate Talks; it has been published by non-governmental environmental groups at major international conferences since the Stockholm Environment Conference in 1972. Internet address: **http://www.igc.apc.org/climate/Eco.html** "The final deal emerging in Berlin looks to be just enough to keep the climate treaty process from collapsing. When Ministers finish congratulating each other and the dust clears, the stark reality of the global predicament will remain unchanged. The build up of $C0^2$ in the atmosphere will not have been slowed by the talks here...."

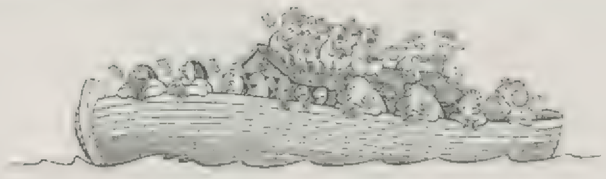
"By implementing policies such as ecological tax reform, utility least-cost planning, energy efficiency standards, and technology commercialization programs, governments can ensure not only necessary greenhouse gas reductions, but positive economic benefits. Demonstrating this in practice during the next two years is the way to turn the opening achieved in Berlin into a genuine emission reduction protocol at COP3 [Third Conference of the Parties]...."

From **"Mission of the Potsdam Institute for Climate Impact Research,"** Potsdam Institute for Climate Impact Research. Internet address: **http://www.pik-postdam.de/about-pik.html** "The PIK was founded in 1992. Its mission is to investigate the consequences of global climate change as a paradigm for the unfolding fundamental crisis between the ecosphere and humanity. Particular attention will be placed on regional aspects such as the consequences of changed rainfall pattern for Central European agriculture and forestry, or the threat to German coastal zones caused by sea level changes as well as increased frequency and amplitude of storms...."

The following books may be of interest to readers, too.

Gates, David M. 1993. **Climate change and its biological consequences**. Sinauer Associates, Inc., Sunderland, Massachussetts. 280 pp.

Pernetta, John, Rik Leemans, Danny Elder and Sarah Humphrey. 1994. **Impact of climate change on ecosystems and species: Marine and coastal ecosystems. A Marine Conservation and Development Report.** IUCN, Gland, Switzerland. 108 pp.



Educating the public about biodiversity

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According to recent developments in the theory of social psychology, laypeople often adopt ideas from science and make them useful for purposes of social discourse by reducing them to what are called "social representations" (e.g. Moscovici and Hewstone 1983). Social representations are usually simpler than the technical concepts they are derived from. At times, in fact, they end up so simplified and distorted as to be scientifically wrong (Moscovici 1984). As causal explanations, they may be useless.

What neither the psychologists nor other scientists seem to have appreciated fully is that scientists themselves are laypeople in disciplines other than the ones they are specialized in. Except perhaps for sister subjects or fields in which they have an amateur interest, their ideas about the sciences they are not personally qualified in resemble those of any other intelligent and well-read layperson. In view of the enormous volume of information a person must acquire in order to master even a single discipline, it could hardly be otherwise.

In this sense, most biologists are laypeople when it comes to the sciences of human cognition. Normally they would have taken, at most, one or two introductory university courses in psychology or a related subject. Therefore when biologists make statements about such matters as public education or public mobilization for the sake of the environment, it often happens that the currency of their thought and language is composed of social representations little different from the ones circulating among, for example, pharmacists.

In other circumstances this state of affairs would matter no more than, for example, the quite possibly simplified or wrong representations biologists have about linguistics. But the world is in the throes of an environmental catastrophe (Wilson 1992), and biologists have become highly influential in shaping environmental policy, including policy that has a bearing on the way the public should be taught about biodiversity in order to improve the standard of environmental citizenship. In these conditions the failure of biologists to realize that they are thinking as laypeople but expressing themselves *ex cathedra* may do real harm.

Claude Villeneuve's article in the Winter 1994 issue of *Global biodiversity* (4(3): 19-24), "Information and Training in Biodiversity: The Paradox of Noah's Ark," usefully illustrates some of these points, not because its faults are worse than those other essays written by biologists on public education and ecology, but because it is representative. In the comments that follow, due allowance must also be made for the fact that "Paradox" was originally presented as an oral address. Here it is scrutinized according to expectations that make no allowances for the context in which it was first delivered.

In the first place, "Paradox" is an article about public education and persuasion, but it is written by a scientist who is apparently not trained in lay cognition or the psychology of persuasion. Of course, scientific writers ought to cross disciplinary boundaries as much as they prudently can. When they make forays into the subject-matters of other sciences, though, and when they are conscious that they are crossing boundaries, they should carry out at least a flying reconnaissance of the literature, citing references. In common with other papers of its kind, "Paradox" reveals little awareness that a social science literature exists on the same sorts of questions as exercise the mind of its author. It cites one publication with social science content.

When biologists are unacquainted with the literature in environmental psychology (the branch of anthropology concerned with ethnoscience, or human ecology), for example, they can make gross errors in characterizing the layperson. Mr. Villeneuve, for example, is mistaken in thinking laypeople have little or no ability to assess the general biodiversity of a landscape (p. 19); and in thinking that "most people have no idea of the diversity of the flora and fauna surrounding them" (p. 23). Even teenagers who grow up in thoroughly humanized regions of Canada do surprisingly well on indices of their ability to assess the relative biodiversity of local ecotopes (Chipeniuk, in press).

Biodiversity is not "a reality more difficult to grasp" for the layperson than for the scientist (p. 19). In most tribal societies any normal adult can distinguish among hundreds, even thousands, of local wild plants and animals, nearly all these kinds corresponding to Linnaean species or genera (e.g. Atran 1990, Brown 1984). How many scientists have the same ability? The problem is that while most people in Canada, the United States, and Europe are capable of recognizing biodiversity, their upbringing fails to give them the kinds of experiences needed to develop the competent and rich sense of biodiversity possessed by human beings in other parts of the world (Chipeniuk 1994; Chipeniuk, in press).

Mr. Villeneuve is wrong, also, in suggesting that "city-dwellers...can only learn about biodiversity through television, books, or visits to botanical or zoological gardens" (p. 20). In fact, research indicates that it is direct, informal experience of nature that attunes individuals to biodiversity in the bio-regions they actually inhabit, and in particular, direct experience through childhood foraging for natural kinds (Chipeniuk, in press; Nabhan and Trimble 1994).

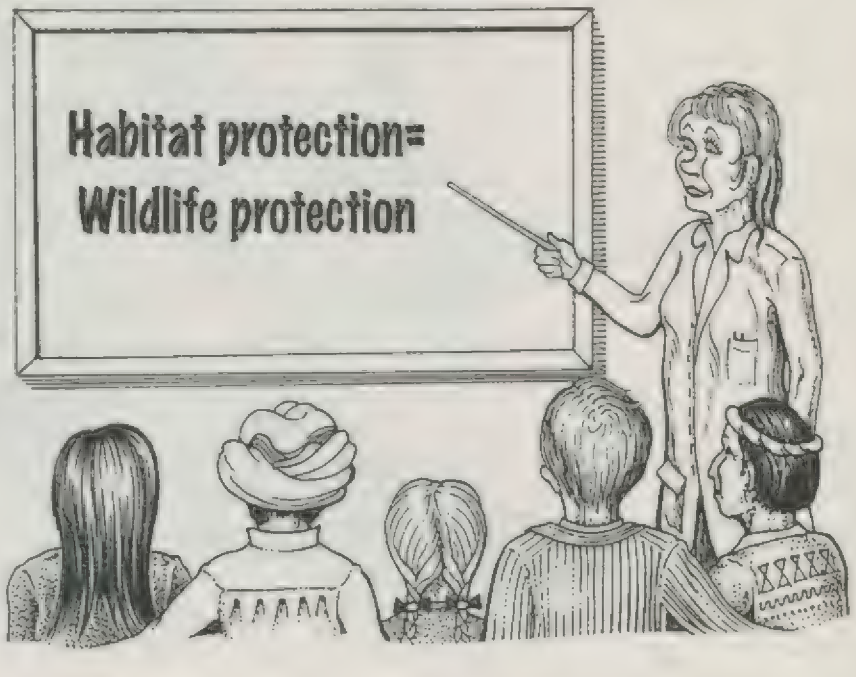
Ironically, when biologists imagine that formal environmental education is the best way to "teach" ordinary members of the public about biodiversity (p. 23), they are themselves captive to a common-sense notion of education. They presuppose that the concepts that allow scientists to understand the natural world are those that will allow ordinary citizens to understand the natural world (p. 22). In other words, ordinary citizens ought to become biologists themselves, only less so. Yet little evidence supports the belief that teaching biology to lay citizens actually transfers lasting concepts, much less that it is the best way to equip laypeople with the ability to think appropriately about biodiversity. On the contrary, cognitive scientists are starting to find that, for purposes of daily life, folk-generated common-sense ideas about the environment can be superior to those half-learned from the sciences (Kempton 1987).

Many conservation biologists seem not to realize that expert thought differs from lay thought. Yet environmental experts are known to think about landscapes in a different fashion from laypeople (Kaplan and Kaplan 1989, Kartez 1989). Ecologists themselves have warned that the scientific mode of understanding is non-intuitive and differs from common-sense modes of understanding (Pickett *et al.* 1994). Because good citizenship depends on citizens making their own individual judgements about important social issues, it may actually be unethical for experts to couch public policy in the concepts and language of, for instance, technical ecology (Kartez 1989, Tong 1986).

More generally, one grows uncomfortable when scientists arrogate the whole of the conservation enterprise to themselves. Instances of this tendency range from naive claims that "the national park concept is based in the Western scientific culture" (Hough 1991) to the rewriting of Canadian national park policy in ecosystem terms. Taken to its extreme, this habit of mind results in delusions that are potentially dangerous, such as the idea, from time to time seriously mooted, of excluding the public from national parks altogether; a move that might all but guarantee the collapse of the national park system by undermining its constituency (cf. Foresta 1991, Hales 1991).

For his part, Mr. Villeneuve attributes the current generation's awareness of how industrialization and economic development are affecting the environment to an "ecological awakening" (p. 19). Yet to the contrary, people were sensitive to the loss of rich and natural ecosystems long before the technical idea of ecology ever existed. Their minds were concentrated on this loss by poetry and philosophy, of all things, at a time when natural landscapes were being changed to cultural ones so fast that people could see the change themselves. Note what happened around Concord during the lifetime of Henry Thoreau (Worster 1994).

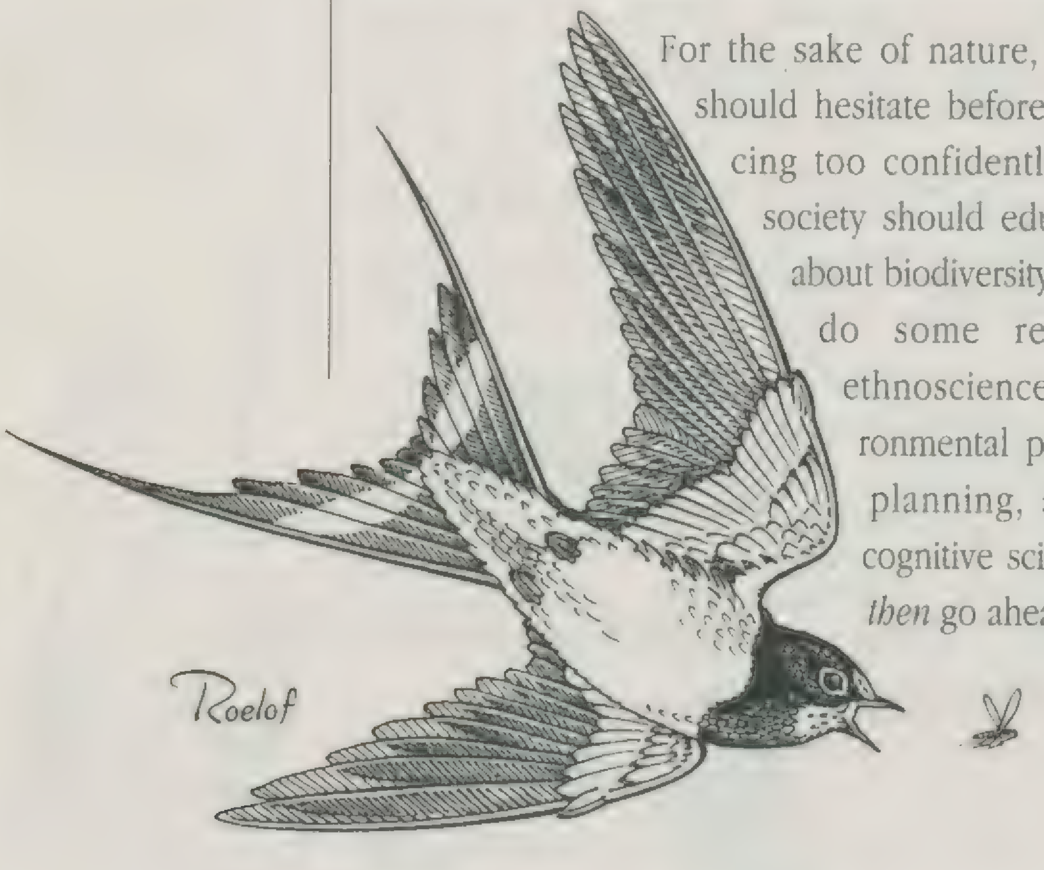
Is formal environmental education the best way to "teach" people about biodiversity?



Mr. Villeneuve's suggestion that scientists are better than members of the general public at appreciating the "true beauty of nature" (p. 22) takes one's breath away. Field biologists may have a more detailed understanding of nature than most of their fellow citizens in technological societies, and they certainly have more opportunities than average to enjoy nature. However, there is not a shred of evidence that the sort of pleasure they take in contemplating nature is different from that of their neighbours. Indeed, one of the greatest of living biologists, E.O. Wilson (1984, 1994) has stated that, in his view, love of nature comes with the human biogram. Of himself and the sources of his own fascination with natural kinds, he has said he keeps alive "the little boy of Paradise Beach who found wonder in a scyphozoan jellyfish and a barely glimpsed monster of the deep" (Wilson 1994: 364).

None of the foregoing should be read as an argument in favour of muting the voice of biologists in conservation policy. Quite properly, biologists have played a leading role in raising world consciousness about the crisis in human relationships with nature and in specifying what is needed to preserve natural ecosystems intact. In national and international policy affecting the environment, their influence has too little. Policy-makers go astray by paying less attention than they should to what biologists have to say—about biology, about ecology, and even about human ecology. Nevertheless, there are some realms of human experience in which biologists must realize their own strong opinions reflect not much more than common sense made heady with a misplaced sense of expertise. Two of these areas are environmental cognition and environmental education.

For the sake of nature, biologists should hesitate before pronouncing too confidently on how society should educate itself about biodiversity—hesitate, do some reading in ethnoscience, in environmental psychology, planning, and other cognitive sciences, and *then* go ahead.



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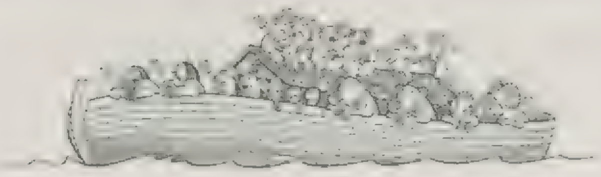
A RESPONSE TO MR. CHIPENIUK



Biodiversity education: Intuitive cognition is far from enough!

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I regret that Mr. Chipeniuk has chosen my article to do a case study on the lack of understanding that scientists can show towards public education matters. Despite his claims, I maintain that certain issues concerning the conservation of biodiversity are very complex and cannot be solved by simple explanations, and others are often oversimplified by teachers and the media.

I would like to put into perspective some of Mr. Chipeniuk's statements on my article.

I have never questioned the usefulness or the relevance of traditional knowledge as implied by Mr. Chipeniuk, but I believe that we must recognize the limits of this knowledge and its applications. Intuitive representations and explanations can be useful up to a certain point to code the relationships with nature in a simple world where tradition serves as a code of conduct. Unfortunately, it is entirely insufficient to predict the changes and the limits of natural systems. It can also be marred by mistakes that can lead to false interpretations and costly mistakes for the conservation of species—even if they have no consequences for the traditional way of life. For example, the James Bay Crees give a different name to the willow ptarmigan in its summer and winter plumage. Everything seems to indicate that they traditionally considered this bird as two different species. Can we, therefore, deduce from the traditional aboriginal representation that this species disappears twice a year? I am not a specialist in this matter, but the aboriginals of the tropical forest must surely make the same kind of mistakes, though this does not mean we cannot use their knowledge to help us understand the ecology of the these complex environments. It is one more tool, but inadequate by itself.

Traditional Chinese pharmacopoeia makes use of the organs of threatened animal species and claims that their properties are as extraordinary as the species is rare. The properties credited to rhinoceros horn powder and seal penises are without a doubt a product of social representation. Should we conclude that they are effective to cure ailments without questioning the relevance of the representation that justifies them on the pretext that it comes from traditional knowledge?

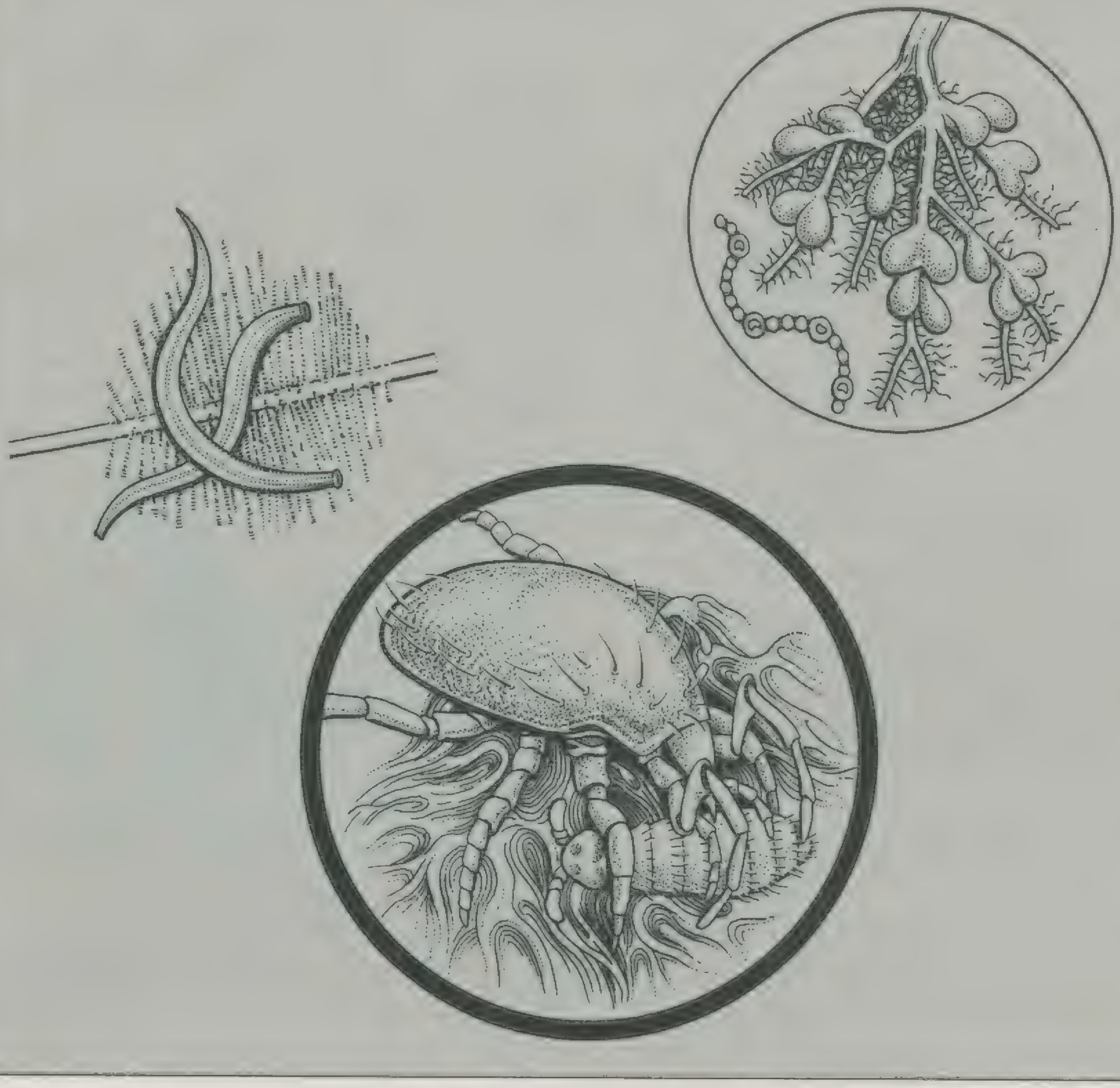
Shouldn't we also consider that the environmental disaster that we are confronted with today is a product of the representation of nature and the traditional common sense of our societies, which purports that nature is boundless and at the service of man?

Moreover, Mr. Chipeniuk states that the North American teenagers have powerful means at their disposal throughout their childhood to understand biodiversity through their contact with nature. I would be very happy to read his article in press on the subject. From my personal experience as an extension biologist, a teacher, and a researcher in science didactics for almost 20 years, I have come to realize that most North American teenagers, particularly city kids, cannot describe a landscape—even a familiar one—and correctly identify the plant and animal species found therein. They know nothing about the aquatic ecosystems and the diversity of insects and archanids that surround them, let alone the soil fauna and flora. Up until they are 18, when they take advanced biology courses, their concept of the microbial world is comparable to that held by people in the eighteenth century, while their concept of heredity parallels the level of knowledge that can be decoded from reading Buffon's writings. (Buffon was a French naturalist in the eighteenth century, remembered for his comprehensive work on natural history, *Histoire naturelle, générale et particulière.*) As far as the idea of evolution is concerned, they are at best lamarckian when they are not definitely creationist. (Lamarckism is a theory of organic evolution asserting that environmental changes cause structural changes in individuals, which are then transmitted to their offspring.) And that despite the secondary school science that gives them scientific vocabulary! For most of them, in fact, the acquisition of the vocabulary is sufficient to succeed at exam time. Science teaching generally fails when it comes to displacing the original concepts. In fact, there is more to understanding biodiversity than being able to name plant and animal species. Detailed knowledge of genetics, ecology, and evolution are required to understand the problems and the complexity of biodiversity.

In 30 years or so, more than 80% of the world's population will live in cities, and it is unlikely that schools will have the means to offer students additional nature trips. The lack of contact and experience with nature will become more commonly the norm as far as the decision-makers of tomorrow are concerned. That Mr. Chipeniuk reminds us of the accuracy of Thoreau's observations will change nothing. Biodiversity and the evolution of the natural landscape will become less and less within the reach of the common person, except through television, books, and visits to botanical gardens and zoos.

I had the opportunity to do my doctoral studies in science didactics at the time when Serge Moscovici published the books that Mr. Chipeniuk likes to cite...the notion of social representation is, therefore, not new to me, even though Mr. Chipeniuk seems to consider my article as the archetype of a text written by a scientist with a mind closed to social sciences.

Before launching himself into an exercise of ethics on the precautions that a biologist should take before talking about biodiversity education, Mr. Chipeniuk should maybe stick more closely to the reality of science education. I look forward to reading his answer in 15 years.



Today most North American teenagers know little about the tremendous diversity and complexity of life—even that found in the soil under their feet. In another 30 years, more than 80% of the world's population will live in cities, and people will have even less direct contact with nature than they do today. How, then, to best teach them about biodiversity and its importance?

The Mission of the U.S. National Biological Service

A good overview of the mission and funding of the U.S. National Biological Service is given in the following excerpts from the statement of H. Ronald Pulliam, Director of the National Biological Service, before the House Appropriations Committee on Interior and other related agencies, 23 March 1995. These excerpts were pulled from Bene-L on the Internet. This description of the roles of the U.S. National Biological Service may be of interest to Americans given the cuts the Service may face, and to Canadians given the pending closure of their Status of the Environment Reporting Unit that performs some of the same roles.

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BACKGROUND

Management and policy decisions regarding the conservation and use of our nation's natural resources directly impact the prosperity and well-being of all citizens. All too often these decisions are based on incomplete, uncertain, or unreliable scientific information, and inadequate information often leads to unjustified and unfair decisions. Disagreements over basic facts, such as "is this species declining or not?", impede discussion and resolution of real problems.

The National Biological Service (NBS) was created to ensure that the science used in management and conservation decisions is sound, unbiased, and freely available. NBS has no regulatory or resource management responsibilities, and our scientific results are not biased by management or regulatory agendas. We are committed to improving the quality of scientific information by having rigorous peer review of our research methods, analyses, and conclusions, and by making our scientific information fully available to all parties involved in and affected by natural resource decisions. Our job is to provide better information so that better and fairer decisions can be made.

NBS is a scientific organization devoted to working with others to provide the information and technologies needed to manage our nation's biological resources. Our primary customers are other Department of Interior (DOI) bureaus, and we focus most of our research on Interior lands and trust species. NBS also has an important role in building a national partnership for identifying biological resource information needs and making existing biological data available. NBS works with other federal agencies, state and local governments, industry, academic institutions, other private organizations, and individual citizens.... Providing better information and making it widely available to all interested parties will aid significantly in resolving natural resource issues before they become intractable.

NBS's mission is not to produce a giant survey of the nation's flora and fauna, and in fact, inventory and monitoring or "survey"... activities account for less than 15% of NBS's budget. It would be physically impossible and of dubious value from a scientific point of view to do a census of all plants and animals in the United States. NBS, however, does provide statistically reliable data on the status and trends of carefully selected biological resources, with a strong focus on Interior lands and trust species. NBS does a limited amount of work on private land; all individuals working on behalf of NBS are required to obey all trespass laws and NBS always obtains written permission from landowners before conducting any new surveys on private property.

The NBS role is to respond to the need for improved information on status and trends by developing and encouraging common methodologies that ensure the reliability of information collected by federal, state, academic, and private entities. Such a common "architecture" can ensure that public and private funds are used efficiently to develop a reliable understanding of the true condition of our resources.

THE NEED FOR SOLID SCIENTIFIC INFORMATION

More statistically reliable information on the status of biological resources is required to support the sound management of our public lands. A recent report on the "Status of biotic inventories in US National Parks" (Stohlgren *et al.* 1995) indicates that most of our national parks do not have good inventories even of their bird, mammal, and vascular plant species. The status of most species of reptiles, amphibians, fish, and invertebrates is virtually unknown, even in the best studied of our parks and wildlife refuges. Despite the lack of this basic information, public lands are increasingly viewed as important refuges for biological diversity, and managers of all public lands are increasingly required to consider biological resources in their management plans.

In addition to managing public lands, the DOI has significant trust responsibilities for migratory birds, anadromous fishes, and threatened and endangered species. Accordingly, NBS has the responsibility for ensuring that better information is available on Interior lands and trust species. One of the benefits of having an independent, non-regulatory science bureau like NBS is that such information can be provided before environmental concerns become crises. Options for action, including voluntary solutions outside a regulatory context, are available, and this is one reason why a number of non-government organizations, including private industries, are working collaboratively with NBS. By working in partnership with private landowners and industry, NBS obtains better information on the status and trends of DOI trust species and provides its partners with valuable information about the way biological resources can be protected without interfering with other uses of their lands....

NBS recognizes that reliable scientific information can "cut both ways," in that it sometimes may be used more for species protection and sometimes more for relief from government regulations. Some information gathered by NBS will please the development community; for example, the "downlisting" of protected species or removal of species from *Endangered Species Act* candidate lists. Some information will result in identifying and resolving problems related to species decline before new listings are required. NBS believes that if accurate information is provided in a timely fashion, it can lead to more "win-win" situations that promote both a prosperous economy and a healthy environment. Since NBS is not a regulatory or management agency, it can devote its efforts to ensuring that better information is available to those who make management and policy decisions. By doing so, better and fairer decisions can be made and conflicts can be avoided.

MEETING DOI BUREAU NEEDS

Although NBS is an independent science bureau, we are committed to providing other Interior bureaus with the responsive scientific help they need. Every year, NBS solicits priorities for biological research from other Interior bureaus and directs its research efforts towards meeting their highest priority needs. We also facilitate regular interaction between our NBS Science Centers and field stations and the local and regional leadership of other DOI bureaus to determine their needs and priorities at the local level. While we are committed to meeting the priority science needs of DOI bureaus and working with them to solve their natural resource problems, the other bureaus do not control the conduct of the research or oversee the dissemination of the research results.

BUDGET OVERVIEW

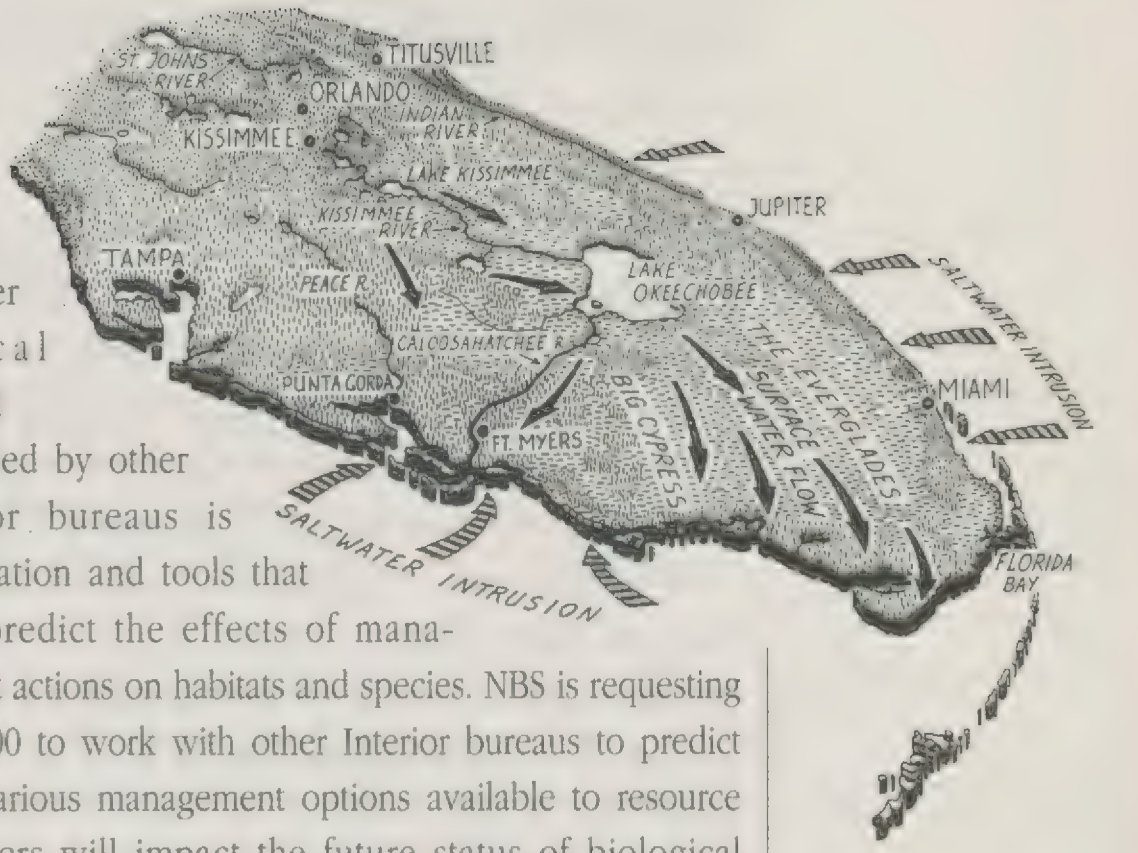
NBS's budget request for the fiscal year 1996 (FY 1996) totals U.S.$172.7 million, which is $5.9 million, or 3.5%, more than our FY 1995 enacted level. We recognize the stringent budgetary constraints confronting all governmental programs and have made significant efforts to redirect existing resources to fund a portion of our new needs, as well as initiating various partnership arrangements to leverage available resources and avoid duplication of efforts.

As part of the President's Reinventing Government Initiative, all Federal agencies are re-examining their mission. This includes: addressing the mission based on "customer" input; asking whether the mission could be accomplished as well or better without Federal involvement; looking for ways to cut costs or improve performance through competition; and finding ways to put customers first, cut red tape, and empower employees. We have been actively participating in this effort since NBS was formed.

NBS is requesting a total of $84.6 million in FY 1996 for Research on Species Biology, Population Dynamics, and Ecosystems. We are continuing to support the Department's focus on key national and local issues in requesting an additional $1.5....million in funding for the Everglades and other habitats of South Florida. Our scientists will work with the United States Geological Survey (USGS) and others to develop hydrologic models and link these with biological models, so as to evaluate the effects on species and habitats of the alternatives for restoration now being considered by the Corps of Engineers. NBS currently co-chairs the Science Subcommittee of the South Florida Ecosystem Restoration Task Force. The task of this subcommittee is to "recommend research and a process for coordinating research on the South Florida ecosystem." In addition to conducting research on the habitat requirements and population dynamics of species, NBS is developing regional databases, coordinating reviews to identify research needs, and developing new predictive models.

We are also seeking an increase of $400,000 for research in the Pacific Northwest. This increase will be used for developing watershed models in critical ecosystems, and to contribute to the understanding of habitat and resource needs of a variety of species, including anadromous fish.

The United States has lost millions of acres of productive land to exotic weeds, especially in the arid West. In addition to reducing the amount of land available for forage and other economic impacts, exotic weeds contribute to a host of ecological problems, including increased erosion and sedimentation and the loss of native species. Techniques for managing and responding to invasive exotic plants on western rangeland is one of the highest priority needs identified by other Interior bureaus to NBS. NBS is requesting $610,000 to understand the factors that make arid grasslands vulnerable to invasion by non-indigenous species, to understand the ecological impacts of these weeds, and to provide information needed to help control their spread.



The unbiased information provided by NBS scientists is key to decision-makers in many areas. In Florida, for example, NBS scientists are contributing to the work of the Corps of Engineers as they decide on the best methods to restore damaged ecosystems. For instance, how can the naturally slow flow of surface water through the Everglades be maintained without drying them up, creating a nutrient burden, or causing saltwater intrusion?

Another critical need identified by other Interior bureaus is information and tools that help predict the effects of management actions on habitats and species. NBS is requesting $800,000 to work with other Interior bureaus to predict how various management options available to resource managers will impact the future status of biological resources of particular management concern on DOI lands. Our approach will include development of user-friendly, multi-species models that allow managers to see how alternative resource management options might simultaneously impact a variety of species with different habitat requirements.

Under the Inventory and Monitoring subactivity, NBS is proposing to increase our efforts in understanding the relationship between social and economic factors and ecological processes. This critical area of research has been identified as an area underfunded by other Interior bureaus and by the Interagency Committee on other Interior bureaus and by the Interagency Committee on Natural Resources. Part of these funds will be used for studies of how economic incentives, such as those for set-asides under the Conservation Reserve Program, impact biological resources....

Another approach will be to work with local and state governments in studies combining models of economic growth with ecological models to determine where future conflicts between economic growth and conservation might occur. Past support for research to understand and avoid conflicts between ecology and economics at the community, state, and regional level has been inadequate even though the link between economic and ecological health has been widely recognized.

Also under the Inventory and Monitoring activity, we are requesting funding to develop a uniform system of ecological classification. Clearly, the existence of multiple systems for mapping and naming forests, grasslands, and other plant communities, and the lack of a means to "translate" from one to another is inefficient. NBS will work closely with the U.S. Forest Service, other Interior bureaus, and the scientific community at large to develop a common approach that meets the needs of all parties conducting ecological mapping and research.

A high priority for NBS is to make existing scientific data and information more accessible to all parties involved in decision making. In the Information Transfer subactivity, NBS is requesting $2.9 million to improve access to biological information through the National Partnership for Biological Science. Much biological information can be found outside of NBS, in government, universities, and museums. We believe that these organizations should continue to be repositories for this information. Our goal is to work with partners to identify, organize, and integrate data so that everyone has access to it via an electronic directory and network.

As a key part of this multi-sector partnership, we are asking for increased funding for our State Partnership program that allows NBS to work collaboratively with state agencies to establish protocols and standards for data collection, analysis, and dissemination. States are important collectors and managers of biological data, and in many cases, serve as primary links to other data holders.

The Cooperative Research Unit program has been the Nation's most successful partnership in fish and wildlife management. This program consists of partnerships for research and graduate education between NBS, state Fish and Game agencies, and universities in 40 states. NBS provides $15 million each year and states contribute at least $12 million annually. The Coop Unit program employs scientists who are nationally and internationally recognized as experts in their field. Collectively these units are involved in over 1,400 research projects as well as in providing technical assistance to the U.S. Fish and Wildlife Service, the National Park Service, the U.S. Forest Service, and others. NBS is seeking an additional $500,000 for this program in FY 1996. This will be used to establish new units in two states. Interested states are being asked to submit proposals for them, and describe the strengths...of potential cooperators and the support that they will provide to a prospective Cooperative Research Unit.

In summary, NBS is a strong scientific organization conducting independent, objective research in support of sound management of the nation's biological resources. It is my hope that the Committee recognizes that too many decisions are made on the basis of inadequate information, that science is best performed by an independent, non-regulatory, and non-advocacy organization, and that NBS is part of the solution, not part of the problem.

Thank you again for the opportunity to be here today. I am happy to take any questions that the Committee may have.

NBS UPDATE/JULY 1995

The United States House of Representatives has passed a budget for the coming fiscal year (beginning October 1) that will reduce the NBS budget about one-third, from a current level of $167.8 million for the year to $112.8 million. The Senate will begin its consideration of the budget in late July. Final action may occur in September or October.

There is grave concern within NBS that reductions of the proposed magnitude will disrupt a wide range of research programs, including such long-term projects as the Great Lakes Fisheries Assessment. This assessment is the principal source of information used by the United States and Canada to set commercial and recreational catch limits for consumable species. It also serves as an indicator to identify population dynamics and trends reflecting effects of pollutants, incursions by exotic species, and other factors that may stress the resource.

Similarly, the Conte Anadramous Fish Laboratory in Turners Falls, Massachusetts, faces potential closure. Key among its many responsibilities is the Laboratory's research on engineering solutions to provide passage for fish around dams, hydroelectric plants and other human obstacles on the river courses that support Atlantic Salmon and other species that migrate between up-river spawning habitat and oceanic living environments.

NBS also collates and analyzes U.S. data collected from Christmas Bird Counts and the North American Breeding Bird Survey, the primary sources of detailed information on a wide range of game and non-game bird populations.

NBS remains committed to providing a high quality, diversified research program for the living natural resources of the United States. This commitment includes continued science support for public land managers, states, non-profit institutions, and corporate or individual private property owners wherever possible. In the process, NBS anticipates expanding its use of the Internet and other computer-related resources to maximize access and distribution of its scientific data and analysis.

How will climate change affect taiga underlain by permafrost?

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Reports from the Permafrost Institute in Yakutsk, capital of the semi-autonomous Yakutia Republic raise concerns over the effects of climate warming on buildings, transportation systems, and ecosystems in northern areas. Some effects are already evident as the top frozen layer of permafrost thaws. Roads and runways crack. Asphalt roads have to be topped off with fresh gravel every year. Buildings tilt. Even railroads built on steel plylons bend out of shape and sink.

Climate warming may mean that the top layer of permafrost that freezes and melts every year will grow from two to five metres. Thus, support piles would have be be driven even deeper into earth than at present, and that the swamp-like summer conditions would be intensified and seasonally lengthened. [*Ottawa Citizen*, p. A2, December 15, 1994].

The ecological effects could be formidable in northern countries, such as Canada. Almost half of Canada, including mountain summits in the Western Cordillera, much of the northern territories, and northern Quebec lie within zones of continuous or discontinuous permafrost. Tundra, for example, occupies 2,303,000 km^2 or about 23% of the terrestrial area of Canada.

In addition, much of the taiga or boreal forest and most of the tundra is underlain by permafrost. The vertical stability of trees is linked to the firm attachment of the root systems, mostly only a few centimetres deep. If the solidity of the soil matrix is weakened, then the trees may topple of their own accord—especially if their trunk position or branch distribution is unbalanced or they are exposed to strong winds. Evidence for this may be seen in areas freshly flooded by roads obstructing the flow of water or by beaver or hydroelectric dams. There, one can see trees on their side with the disk of roots often vertical. Trees tilted or uprooted by this process either grow more slowly or die. Thus, one could expect tundra plant growth to diminish and plant mortalilty to increase in areas where the permafrost under the tundra thaws more than normal.

Given the above scenario, reduction of tree and herb cover would have two consequences. Animals and microganisms, which depend on these plants for food or habitat, may diminish in numbers or variety. These hypotheses could be tested by measuring plant and animal diversity before and after the thawing of the permafrost. There may even be some areas previously surveyed, where permafrost has now been reduced, to compare new results against older results.

The second possible consequence would be a reduction in ecological functions or services. For example, photosynthesis, oxygen production, carbon banking, structural habitat creation, and other ecological functions would be reduced. (For more on ecological functions, see "A conceptual framework for the ecological functions of biodiversity" by Ted Mosquin in *Global biodiversity* 4(3): 2-16.) Because tundra and taiga underlain by permafrost occupy such a significant area of the northern hemisphere, this effect could be significant. For some functions, loss of plant cover area might be counterbalanced by elevated rates of plant productivity at the higher temperature resulting from climate change. Other functions might be unaffected or even reduced by the higher temperature.

Biodiversity news

Views of the public on the environment and the *Endangered Species Act*

The National Wildlife Federation conducted a poll in early December 1994 that indicated, among other things, that 60% of those polled believe environmental laws should be strengthened or maintained, and 57% supported the *Endangered Species Act*. For more on this poll, contact: NWF/1400 16th St., NW/Washington, DC 20036/USA/Tel: (202) 797-6800.

The Times Mirror National Environmental Forum Survey, conducted in April and May 1994, showed similar broad support for environmental protection. A summary of this poll was reported in a recent *Audubon Activist* newsletter by the National Audubon Society. For more information, contact: Brock Evans/Vice-President/National Audubon Society/666 Pennsylvania Ave., SE/Washington, DC 20003/USA/Tel: (202) 547-9009. [John Stahmer, Headwaters, Ashland, OR 97520]

Luminous plant clocks—making mutant genes visible

Biologists have known about circadian biological clocks that regulate daily biorhythms in animals for many years. The mutant biorhythms in animals, such as day-running mice, out-of-synch flight in fruitflies, and diurnal changes in dermal pigmentation, are often obvious. The mutant biorhythms of many plants on the other hand are often obscure. Recent studies by Andrew J. Millar and colleagues (*Science* 267: 1161 and 1163, 24 February 1995), have shown that plant biorhythms can be visually demonstrated with firefly bioluminescence. Using genetic engineering, a luciferase gene from the firefly was linked to a plant's (*Arabidopsis*) clock-regulated gene (CAB) that is normally switched on during the day and off at night. When sprayed with luciferin, the normal plants glowed during the day, while nocturnal mutants glowed at night. All the scientists had to do was to look for seedlings that glowed at the wrong time to find mutants. Finding mutants can help research, breed new varieties, or test whether new chemicals are harmless or cause mutations.

Contract with nature

The 10 March 1995 issue of *Science* (267: 1427) has a short piece in the "Random Samples" section, entitled "Message in a Bottle." It describes how Thomas Eisner of Cornell, in his March 2nd appearance in Washington, DC, stated that the United States needs a "Contract with Nature" (analogous to CONWAM, the CONtract With AMerica). At this appearance, he described the Endangered Species Coalition's Medicine Bottle Campaign, which calls for strengthening the *Endangered Species Act* and recognizing the values of biodiversity.

For more information, the Coalition can be contacted by snailmail at: Endangered Species Coalition/666 Pennsylvania Ave., SE/Washington, DC 20003/USA/Tel: (202) 547-9009.

The text of Dr. Eisner's prepared remarks was previously posted and is in the BENE document archive at URL: **ftp://keck.tamu.edu/pub/bene/bene_texts/te_030295.txt**

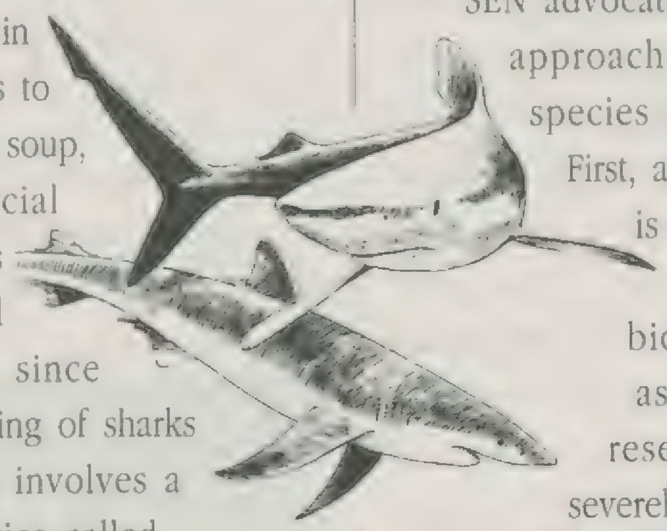
Global biodiversity article spurs positive action

The Summer 1994 issue of *Global biodiversity* featured an article on consumer-supported or community-shared agriculture (CSA) by Jamie MacDonald. CSA is a practice in which the farmer receives payment for crops directly from consumers at the beginning of a season, with both farmers and consumers sharing the crops or crop losses. In researching the article, Mr. MacDonald spoke with a number of local farmers and consumers. His discussions and enthusiasm, along with a number of articles and interviews in other publications and the media, contributed to a ground swell of public interest. This interest has led most recently to the formation of a certified organic CSA project in the Kitchener-Waterloo region of Ontario. A group of eight Old Order Amish farmers in the Milverton area, west of Kitchener, will be supplying 32 varieties of vegetables to approximately 50 families. A full share, which will provide for a family of four, is $448. Half shares for smaller families are $224.

The Milverton CSA is an exciting opportunity for non-farm families to get a wide variety of fresh organic vegetables at a good price and at the same time to help strengthen a rural community. This will provide several farmers with a dependable source of income and let them diversify their operations to protect against losses from crop failure. It is also hoped that it will spur the supermarkets to feature locally grown pesticide-free produce in response to public demand. For more information, contact Jamie MacDonald at: (519) 578-8603.

Launching of Shark Education Network

William Burns, Director of the Pacific Center For International Studies, announced the launching of the Shark Education Network (SEN) in Madison, Wisconsin. The network is comprised of three organizations concerned about the status of sharks worldwide: the Pacific Center for International Studies, Madison, Wisconsin; Conservation Network International, Tevernier, Florida; and the International Association for the Conservation of Chondrichthyes, Vaud, Switzerland. SEN will attempt to heighten public awareness of the plight of sharks, which are being killed at the rate of more than 100 million annually. According to Burns, sharks are at risk as a result of a variety of human activities. As a consequence of increasing demand for shark meat and fins, used in some countries to make shark-fin soup, the commercial catch of sharks has doubled every year since 1986. "Harvesting of sharks for fins often involves a barbaric practice called 'finning', where fishermen cut off the shark's fins and throw the bleeding creature overboard to drown," Burns stated. Shark jaws can also fetch as much as U.S.$5,000 apiece.



Blue sharks by Charlie Douglas, courtesy of Canadian Museum of Nature.

Recreational demand for sharks has also exploded in recent years. Overall, the combined commercial and recreational catch in U.S. waters alone now exceeds the maximum sustainable yield by more than 5,889 tonnes.

Driftnets, used extensively in the fishing industry, also pose a significant danger to sharks. Most sharks that are caught in such nets drown before they can be released. "As a consequence," Burns stated, "millions of dead sharks are left to rot on the ocean bottom each year."

Burns pointed out that the over-fishing of sharks poses an immediate threat to the animals because they do not reproduce quickly enough to withstand the human onslaught that has occurred in recent years. "Female sharks gestate for as long as two years, longer than any other animal," Burns stated. "Many species of sharks have less than dozen young in a litter, and some species, such as the lemon shark, have as few as two. Furthermore, sharks do not mature for 10 to 18 years, and females only produce three or four litters during their lifetime."

SEN advocates a three-prong approach to save shark species from extinction. First, additional research is necessary in the fields of shark biology and stock assessment. Such research has been severely underfunded in the past. Second, effective shark management regimes must be established as quickly as possible. According to Burns, the U.S. National Marine Fisheries Service's recently promulgated regulations for the Atlantic fall short of effectively protecting sharks, but ultimately may serve as a model for other nations. Finally, extensive public education is needed to pressure policy-makers to enact measures to protect sharks. "We must change the public's attitudes about sharks," said Burns. "If people continue to believe that sharks are maniacal 'Jaws'-like killers, intent on attacking and devouring innocent human beings, it will be impossible to gain support for programs that protect them, or to discourage people from ordering shark steak or shark-fin soup at a local restaurant. That is why we have launched the SEN."

Through publications designed for the general public and students, as well as presentations in communities throughout the country, the SEN will work to dispel the popular myths associated with sharks, as well as to emphasize the ecological importance of sharks. "Sharks," Burns stated, "are far more important from an ecological standpoint than whales. They are predators at the top of the food chain and control the populations of other species in the ocean by culling out the sick and diseased ... and thereby, insuring the long-term viability of many species."

"Sharks have existed on this earth for over 400 million years," Burns stated, "yet we have pushed many species to the brink of extinction in only a few decades. I encourage people to write or call the Center, and join us in this very important fight."

For more information contact: William C. Burns/Pacific Center For International Studies/33 University Square, Ste. 184/Madison, WI 53715-1012/USA/ Tel: (608) 257-6309/Fax: (608) 257-0417/ e-mail: **pcis@binc.net** or **ecoguy2336 @aol.com**

India presses U.S. to ratify Biodiversity Convention

India says it will seek to block American access to medicinal plants and other biological material from the Third World unless the United States ratifies the international Biodiversity Convention by this summer. The United States is the only major developed nation that has not ratified the treaty. It has been signed by 171 nations and ratified by 120.

"The mega-biodiverse countries of Latin America, South and South-east Asia are waiting for India to take the lead," Indian Environment Minister Kamal Nath said. "If we do not have progress this summer then we will meet to map out a joint strategy on the transfer of genetic material." [*New York Times*, 23 April 1995, by Sanjoy Hazarika, New Delhi]

Canadians rank highest in environmental awareness

Residents of Canada, New Zealand, Britain, Norway, and the Netherlands ranked the highest in a survey of knowledge about the environment and science. Polish citizens came in last among the 20 countries studied.

The University of Chicago's National Opinion Research Center said the survey, timed to coincide with the 25th anniversary of Earth Day, posed 12 questions on issues ranging from radioactivity and chemicals to the greenhouse effect, evolution, and the impact of automobiles on air pollution.

Canadians topped the list with an average of 7.6 correct answers followed by residents of New Zealand and Britain with 7.5, Norway with 7.2, and the Netherlands with 6.8. An average of 1,267 people were questioned in each country. The other 15 countries, ranked in order by level of awareness, were Northern Ireland, the United States, the former East Germany, the Czech Republic, the former West Germany, Ireland, Japan, Italy, Israel, Hungary, the Philippines, Slovenia, Spain, Russia, and Poland.

The research unit said the results are sobering since even the Canadians answered fewer than 8 of the 12 questions correctly. [Reuters, Chicago]

Gorton Rider raids forest

The House and Senate have passed the so-called Gorton Rider to the Recission bill. The rider requires the U.S. Forest Service to sell six billion board-feet of timber from U.S. national forests in the next two years. It also suspends all environmental laws and judicial processes with regard to the sales. According to informed environmentalists, this bill will mean the end of the last roadless areas throughout the West, particularly in the Rocky Mountain states and the likely end to ancient forests in the Pacific Northwest, with some exceptions.

The bill was written by Slade Gorton of Washington state, a timber industry representative who has admitted accepting U.S.$34,000 in campaign donations from the timber industry last year. [**bene@straylight.tamu.edu**] The bill was prevented from passing into law by presidential veto although this does not rule out later acceptance of an amended bill. [D.E.M.]

No good news in federal budget for museums

Paul Martin's budget for the Canadian government, 27 February 1995, contained little good news for museums. The Department of Canadian Heritage, which funds museums, received massive cuts totalling $676 million over three years. These cuts will be spread over the Department's activities including the national museums, Parks Canada, cultural industries, and sports.

It appears that Mr. Martin has accepted some of the Canadian Museums Association's (CMA) prebudgetary advice, namely not to make any further cuts to the Museums Assistance Program (MAP). However, MAP is being subjected to cuts of just over one million dollars announced three years ago by the previous government. MAP's appropriation level has thus slipped from an intended $18 million to its new level of $11.58 million.

The national museums are each receiving a significant cut in the range of 6% to 7% per year. The cuts are deep enough to threaten many of the national programs offered by these institutions. The CMA is very concerned that these museums might become purely Ottawa-centred. [John G. McAvity, CMA]

World premiere of film on conservation of Ethiopian farmers' seed varieties

The Unitarian Service Committee of Canada and Rollframe Productions presented the Canadian film premiere of *Ethiopia: Feeding the future; the seeds of survival story* at the Canadian Museum of Nature, Ottawa, Ontario, 24 April 1995.

This film presents the story of a fascinating agricultural program based in Ethiopia. Traditional farmers and scientists are working together to restore Ethiopia's food security by recovering, multiplying, and enhancing heritage (landrace) crop seeds. Because these heritage crops are highly adapted to local ecosystems and climate conditions, they are grown without chemical fertilizers or pesticides. They currently outperform the modern varieties that need increasing amounts of fertilizers and pesticides.

At the same time, these seeds (i.e. wheat, barley, sorghum, legumes, etc.) provide essential genetic material for food crops and the development of new varieties in countries like Canada. The protection of biodiversity is an important component of the program.

The film shows unique footage from Ethiopia and demystifies our perceptions of that country. It is beautiful to watch, besides being highly relevant and informative.

For fans of James Keelaghan (Juno award winner 1994), it features him as narrator and with his original music. Mr. Keelaghan was present at the premiere. For more information about the film contact: Friederike Knabe by e-mail at: **au579@freenet.carleton.ca**

Wheeler fills biosystematics position at McGill University

In *Global biodiversity* 3(1), I discussed positive steps to overcome cutbacks to the research and training programs in systematic entomology. One such step was to fill three vacant positions at each of the following institutions: the University of Alberta, Carleton University, and McGill University. As a follow-up to my article, I am pleased to announce the appointment of Dr. Terry Wheeler as Professor of Entomology in the Department of Natural Resource Sciences at the Macdonald Campus of McGill University.

Dr. Wheeler obtained his doctorate at the University of Guelph, Ontario and performed his post-doctoral work at Carleton University, Ontario. At McGill, he will be teaching the next generation of students the expertise required to develop the science of biosystematics as applied to insects. Dr. Wheeler will carry out his research in systematics and biodiversity at the Lyman Entomological Museum and Research Laboratory and also, at the Macdonald Campus. Biodiversity is the unopened book; Dr. Wheeler's work will hopefully open the book and provide the language of learning. Dr. Terry Wheeler can be contacted at: Department of Natural Resource Sciences / McGill University/ Macdonald Campus / Ste-Anne-de-Bellevue, Quebec H9X 3V9/ Canada/Tel: (514) 398-7937/ Fax: (514) 398-7990. [Roelof Idema]

Dr. Terry Wheeler is a new Professor of Entomology at McGill University.

Canadian model forests—active and alive!

In October 1994 the Fundy Model Forest hosted the annual meeting of the Model Forest Network. Workshops and addresses included:

- "The Public View of Forestry Practices in Canada" by Dr. Barry Watson
- "The Elements of Integrated Forest Management" by Dr. Thom Erdle
- "Biodiversity Objectives for Forestry," by Dr. Bill Freedman
- "Recreational Needs that Should be Incorporated into an Integrated Management Plan" by Albro Cowperthwaite
- "Integrated Management on a Woodlot in New Brunswick" by Lawrence McCrea and Brian Belyea
- "Changes in Industrial Forest Management in New Brunswick," by Robert Eastwood and associates
- "Toto, this isn't Kansas: Changes in Integrated Forest Management" by Dr. Fred Brunnell.

Participants also had a chance to talk with representatives from two

MODEL FOREST
NETWORK
RÉSEAU DE
FORÊTS MODÈLES

Mexican model forests, twinned with Canadian model forests. "While there may be physical and social differences, the goals of the projects are the same." [*Horizons* 2(1), Winter 1995, Fundy Model Forest]

The Manitoba Model Forest has been involved in comparing a "cut-to-length" harvesting system with a "full-tree" system. This study involved the evaluation of logging equipment in field trials and associated studies and will continue through 1995 and into 1996. Dr. Jennifer Shay, of the University of Manitoba Botany Department, will perform follow-up botanical studies to note vegetation change, succession, and persistence of site damage in the study areas in comparison to her 1994 findings.

The Canadian Pulp and Paper Association, Woodlands Section presented the 1994 Fraser Inc. Award to Harold Peacock and Glen Pinnell for their paper on the results of the first part of this study. Copies of the paper, which looks at advantages and disadvantages of the two systems, are available from the Model Forest Office." [*Down to Earth* 2(2), April 1995, Manitoba Model Forest]

The Canadian Model Forest program does not yet include a selective logging project, and Canada's eco-forestry institutes and foundations are not yet involved. [D.E.M.]

British Columbia students take action for local biodiversity

As they have for centuries, wild Rocky Mountain Bighorn Sheep winter on the grasslands, slopes, and rocky crags where the village of Radium Hot Springs, B.C. sits today. Occasionally, cougars have even been sighted in and around the village.

These animals, therefore, offered an appropriate choice of projects for Radium students to prepare and present at the 1995 "All About Biodiversity" Conference held in Invermere, B.C., in May. The conference, attended by 170 people, encouraged students to develop and present projects about local biodiversity topics to present to attendees.

Macauley Deck, Kyla Smith, Laura Frederickson, and Kelsey Verboom present their display on Bighorn sheep at the "All About Biodiversity" Conference 1995. (Photo courtesy of Bill Swan.)

However, the Radium students from Grades 4 and 5 did not stop with this effort. Building on the success of their two interactive and informative displays at the conference, the students produced brochures, one on cougars and one on bighorn sheep, for distribution to Radium businesses, residents, and visitors. The students also presented their brochures, explaining the biology and ecology of these creatures, to Town Council and neighbouring Kootenay National Park. Congratulations on a fine effort to the students and teachers of Radium Elementary School.

The success of the 1995 conference has inspired plans for an "All About Biodiversity" Conference 1996. Persons wishing more information on the 1995 conference, or to participate in or sponsor the 1996 event are encouraged to contact Bill Swan/ Education Coordinator/Kootenay National Park/Box 220/Radium Hot Springs, B.C. V0A 1M0/Tel: (604) 347-9615/Fax (604) 347-9980.

Congratulations to poster winners

In April the Canadian Coalition for Biodiversity (composed of Canadian Biodiversity Institute, Canadian Nature Federation, Falls Brook Centre, Friends of the Earth, Rare Breeds Canada, Ocean Voice International, Sierra Club of Canada, and West Coast Environmental Law) organized a poster competition for youth focused on the theme "What biodiversity means to me." Over

1,000 entries were received and were judged by a panel from the artistic community around the Falls Brook Centre in New Brunswick.

Congratulations to all the winners. The first place winners were Jennie Schueler, Oxford Station, Ontario (Grades 1-3), Amy MacDonald, Hartland, New Brunswick (Grades 4-6), Jamie Keefe, Black Tickle, Labrador (Grades 7-9), and Grace E.H. Gihm, Vancouver, B.C. (Grades 10-12). As part of the World Environment Day celebration in Montreal, these winners met Environment Minister Sheila Copps at an awards presentation.

An exhibit of the best submissions as well as the winning entries will be displayed at the House of Commons in Ottawa this fall. The purpose of the exhibit is to demonstrate to Canadian Ministers of Parliament how important biodiversity is to children from across Canada. [Canadian Coaltion for Biodiversity]

This artwork by Amy MacDonald of Hartland, New Brunswick was the winning entry in the Grade 4-6 category.

Cyberdiversity:

Biodiversity and the Internet

Earth Council in Costa Rica on the Web

The Earth Council in San José, Costa Rica, has inaugurated a World Wide Web (WWW) Server on the Internet. Among other roles the Council functions as an omsbudsperson for the Earth. The Council's server will provide information on the Council's program and activities as well as information on sustainable development issues to the global community. The first stage of the project was funded by the International Development Research Centre (IDRC). Costa Rican President José María Figueres inaugurated the server at the Council's annual meeting. The WWW server may be reached at the following URL: **http://terra.ecouncil.ac.cr/ecweb.html**

Biosphere Reserves in Canada on the Web

The Biosphere Reserves in Canada Newsletter, part of the UNESCO Man and the Biosphere Programme, is now published on the WWW. With a connection to the Internet, and using a browser such as Mosaic or Netscape, one can access this newsletter by browsing the following URL:

http://www.digimark.net/iatech/unesco/mab.html

Brazilian Ecosystem on the Web

The Tropical Data Base is pleased to announce the new directory "Brazilian Ecosystems." The first one to be launched is the "Atlantic Rain Forest," which can be reached at: **http://www.bdt.org.br/mata.atlantica/**

It includes links to the databases (in Portuguese):

1. *Priority Areas for the Conservation of the Atlantic Rain Forest of Northeastern Brazil*, a workshop held in December 1993 in Brazil, sponsored by Conservation International, Fundaçao Biodiversitas and Sociedade Nordestina de Ecologia. The database includes the workshop proposal, conclusions, bibliographic and geographic databases, and maps generated by the software CISIG. It's available at: **http://www.bdt.org.br/mata.atlantica/workmata/**
2. *Arboreal Species of the Atlantic Rain Forest*, the result of a bibliographic survey. Includes the list of species, bibliographic databases and tables about geographic distribution. Go to: **http://www.bdt.org.br/mata.atlantica/arboreas.html**

3. *Brazilian Researchers Studying the Atlantic Rain Forest,* a subset of the "Who's Who in Biodiversity in Brazil" database, includes information such as contact address, e-mail (when available) and research interests. Go to: **http://www.bdt.org.br/cgi-bin/bdtnet/whobiomata**

Posted by:
Patricia de Oliveira/Base de Dados Tropical/Fundacao "Andre Tosello"/ <<**http://www.ftpt.br**>> <<**gopher://gopher.ftpt.br**>> <<**patricia@ftpt.br**>>
Tel: +55 192 427022/Fax: +55 192 427827

Michigan habitat loss reported on Great Lakes Environmental Wire (GLEW)

Urban sprawl and other poor land use decisions are among the top environmental problems in West Michigan, according to a panel of experts. The survey is part of a special report on West Michigan's environment by the Grand Rapids Press. You can find it on the Great Lakes Environmental Wire.

The report also contains stories about Lake Michigan dune preservation, the growth in the number of environmental lawyers, the state of environmental education. Also on GLEW at the time of survey: An analysis of the fundamental changes proposed for the state's toughest pollution law; the Air Force's desire to drop six sites from the Wurtsmith cleanup; Washtenaw County's appeal of a federal ruling for a hazardous deep well injection site; and the sprouting of a 70-acre rainforest sprouts under glass in Grand Rapids.

You can find GLEW under the regional news link of the Great Lakes Information Network at: **http://www.great-lakes.net:2200/0/glinhome.html**
or under NEWS at:
gopher.great-lakes.net

Contacting the Biodiversity Convention's Interim Secretariat

The address for the Interim Secretariat for the International Convention on Biological Diversity is as follows:

Convention on Biodiversity/Geneva Executive Center/C.P. 356/CH-1219 Chatelaine, Switzerland/Tel: (41-22) 979 9111/Fax: (41-22) 797 2512/e-mail: **adayao@unep.ch**

UNEP biodiversity publications to be available on the Net

Ian Barnes of the World Conservation Monitoring Centre (WCMC), Cambridge, U.K., notes that he has noticed a number of requests for the following publications by UNEP/WCMC:

1. "Guidelines for Conducting a National Institutional Survey"
2. "Data Flow Model"
3. "Guidelines for Good Biodiversity Information Management Practices"
4. "Biodiversity Information Management Resource Inventory"

These documents are in draft form. Final comments from UNEP, which were to be delivered to WCMC on May 3, will be incorporated. The documents will be released approximately three weeks later on our ftp site. We will announce this at the time.

Please note that the personal contact for these documents is John Busby, at:

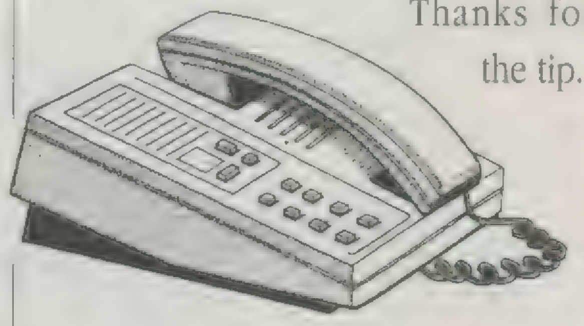
john.busby@wcmc.org.uk

[Ian Barnes/WCMC/219 Huntingdon Rd./Cambridge, CB3 0DL/ Tel: 01223 277314/Fax: 01223 277136/WWW: **www.wcmc.org.uk** FTP: **ftp.wcmc.org.uk**]

Access the views of the Ecological Society of America

The Public Affairs Office of the Ecological Society of America has been focusing on specific major environmental policy decisions currently facing the Congress using: the Daily Environment Report, Bureau of National Affairs Inc., Washington, DC; Congressional Green Sheets, Environmental & Energy Study Institute, Washington, DC.; *The New York Times,* New York, NY. You can visit their new home page on the WWW (if you have Mosaic, Netscape, or similar program) at:
http://www.sdsc.edu/1/SDSC/Research/Comp_Bio/ESA/ESA.html

OUR READERS PHONE...
When a reader phoned the National Science Foundation's division of environmental biology about the PEET program (Global biodiversity 5 (1): p. 27), he was informed that the program is no longer running. Thanks for the tip.



Biodiversity meetings

29 SEPTEMBER-1 OCTOBER 1995
Midwest Bioarcheology and Forensic Anthropology Association Second Annual Meeting, to be held in DeKalb, Illinois, U.S.A.

Contact:
M. Smith or D. Hodges
Department of Anthropology
Northern Illinois University
DeKalb, IL 60115
U.S.A.
Tel: (815) 753-0277
Fax: (815) 753-6900

1-4 OCTOBER 1995
Engineering Plants for Commercial Products /Applications, to be held in Lexington, Kentucky, U.S.A.

Contact:
Monica Stoch
Conferences, University of Kentucky
218 Peterson Service Building
Lexington, KY 40506-0005
U.S.A.
Tel: (606) 257-3929
Fax: (606) 323-1053
e-mail:
monica.stoch@ukwang.uky.edu

17-19 OCTOBER, 1995
Advancing Boreal Mixed Wood Management in Ontario, to be held in Sault Ste. Marie, Ontario, Canada.

Contact:
C. Rodney Smith, Chief, Research Applications and Liaison
Canadian Forest Service
1219 Queen St. E., P.O. Box 490
Sault Ste. Marie, ON P6A 5M7
Tel: (705) 949-9461
Fax: (705) 759-5700

23-27 OCTOBER 1995
Second International Congress on Utilization of Tropical Plants and Conservation of Biodiversity, to be held in Douala, Cameroon.

Contact:
Thomas Tata-Fofung
BDCP-Cameroon
B.P. 292
Yaounde,
Cameroon
Tel: (237) 31-4125
Fax: (237) 31-4125

or

BDCP U.S.A. Office
Fax: (301) 890-4121

31 OCTOBER -2 NOVEMBER 1995
Environment and Energy Conference, to be held in Toronto, Ontario, Canada.

Contact:
Solar Energy Society of Canada
2415 Holly Lane, Suite 250
Ottawa, ON K1V 7P2
Tel: (613) 523-0974

or

Doug Lorriman
Tel: (905) 873-3147
Fax (905) 873-2735

or

Steve Carpenter
Tel: (519) 884-6421
Fax: (519) 884-0103

3-6 DECEMBER 1995
Biodiversity, Conservation and Management at the Beni Biosphere Reserve, Bolivia, to be held in La Paz, Bolivia.

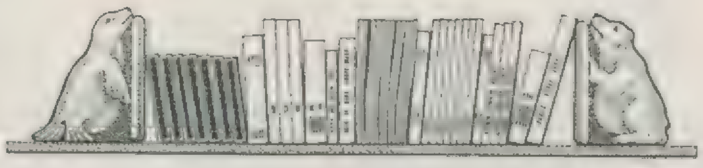
Contact:
Carmen Miranda
Academia Nacional de Ciencias de Bolivia
Av. 16 de Julio 1732
Casilla 5829, La Paz, Bolivia
Tel. or Fax: (591-2) 350612
e-mail: **cmiranda@ebb.bo**

Francisco Dallmeier
Smithsonian/MAB Biodiversity Program
1100 Jefferson Drive S.W., Suite 3123
Washington, DC, 20560
U.S.A.
Tel: (202) 357-4793
Fax: (202) 786-2447
e-mail: **ic.fgd@ic.si.edu**

26 NOVEMBER-1 DECEMBER
Sustainable Agriculture for the Tropics: The Role of Biological Nitrogen Fixation, to be held in Angra Dos Reis, Brazil (about 120 km from Rio de Janeiro).

The conference will honour the research accomplishments of Dr. Johanna Dobereiner, and speakers from 13 countries are currently scheduled. Your are invited to present posters, and additional oral presentations may be accepted.

Contact:
Dr. Avilio A. Franco
EMBRAPA-CNPAB, Km 47
Estrada Antiga Rio Sao Paulo
Seropedica, ITAGUAI, 23851-970
Rio de Janeiro,
Brazil
or e-mail:
John Richards
richards@biochem.wisc.edu



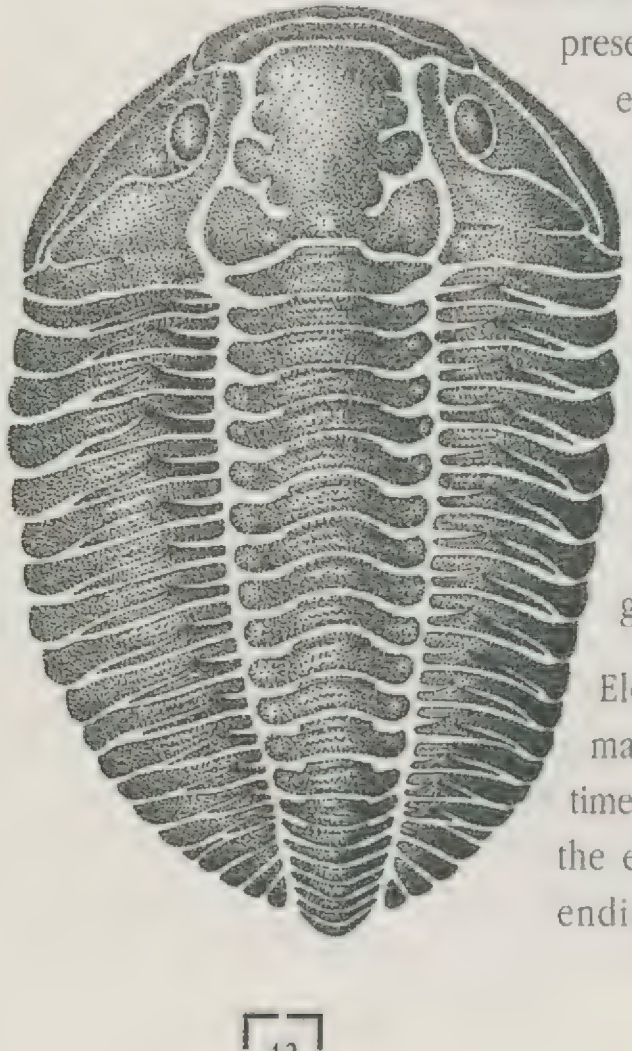
Book and Periodical Niche

The Miner's Canary: Unravelling the mysteries of extinction

By Niles, Eldredge. 1994. Princeton Science Library series, Princeton University Press, Princeton, New Jersey. i-xviii + 246 pp., ISBN 0-691-03655-1, paperback, US $12.95.

This inexpensive paperback edition of the original 1991 volume by Eldredge (Prentice Hall Press, New York) is a welcome addition to the Princeton Science Library series. *The Miner's Canary* is both a treatise on the root causes of extinction and a personal environmental essay by the author, who is Curator of Invertebrates at the American Museum of Natural History, New York. As do most palaeontologists, he views life on the planet on a grand scale, set against a time frame of hundreds of millions of years' duration. Eldredge studies trilobites, a large group of primitive arthropods that have been extinct for the last 240 million years. It is the extinction process, and man's role in the current round of extinctions, that he addresses here.

Eldredge studies trilobites, a large group of primitive arthropods that have been extinct for the last 240 million years. It is the extinction process, and man's role in the current round of extinctions, that he addresses in *The Miner's Canary*.



This book is in the realm of popular science, presenting a weighty topic clearly and engagingly, referring often to the work of others but unburdened by footnotes. Other than the cover photograph (an Upper Jurassic fossil pterosaur from Germany) and a geological time scale in the introductory pages, the book is without illustrations. It concludes with a 17-item annotated bibliography and a useful index.

Eldredge acknowledges six global mass extinction events in geologic time, starting 510 million years ago at the end of the Cambrian period, and ending with the end-Cretaceous extinction event 65 million years ago that killed off the dinosaurs and many other less famous taxa. He takes us gently through a survey of these events and the controversial discussions by proponents of a number of causal, game-over theories. On the way, the reader manages to learn a lot about biological and geological theories and processes, from diversity to niche width and island biogeography to the reproductive isolation of African cichlids to how the biota of the tropics differs from that of the tundra, and the impact seafloor spreading, iridium spikes, and global cooling have on this debate.

Eldredge does a good job of discussing the work of the major players in the extinction debates, and through well-chosen biological examples, in showing how complex the issues of extinction, and the other side of the coin, evolution, really are. By examining the various extinction events, he tries to show how the world works; the biological premise behind it all. His overarching theory of extinction goes something like this: regardless of the triggering event(s), species become extinct more often due to habitat destruction and change (in size and location) than to direct slaughter. Organisms will rarely go extinct if suitable habitat remains open to them.

Eldredge's personal essay conveys his conviction that the human species is accelerating change, particularly habitat destruction, at a rate that will surely cause the next global mass extinction. He is unwilling to accept the philosophy that extinction events are an evolutionary "cleansing" that allows the Phoenix-like rebirth of life in different forms. Eldredge argues that the name of the game of life is not future evolution, but survival. He acknowledges that the human species would probably not be here today if dinosaurs had survived the Cretaceous extinction, but that as sentient beings, "once here, it is only natural that we want to avoid extinction." By actively working to conserve the genetic diversity of the planet, we maintain the status quo by surviving and by helping the components of all the world's ecosystems survive. He notes, ironically, that if our species' efforts to stem the global tide of species and habitat destruction are successful, this success will have more evolutionary impact than the extinction of our species or of any other.

The question hanging, of course, is this: what about changes beyond human control, such as seafloor spreading, bolide impacts, and volcanism? It is naive to think that over the long run humans can stop the ongoing processes of natural change that have resulted in the previous extinction events of the last half billion years. Ultimately the world will change along with its species composition as we know it. Eldredge's approach will not stop planetary evolution in its tracks. It will, however, extend the lineage of our species and many others by generations, and will ensure a more pleasant and familiar environment for us all.

The Miner's Canary is compelling reading, and I recommend it to a wide audience. Eldredge's plea is for awareness—awareness of the interconnectedness of life and of the consequences of contributing to what some have termed an approaching biotic holocaust. The original miner's canary was, of course, an early warning system of impending disaster, and the author is doing his best to play the same role and ring the alarm. In so doing, however, he paints a beautiful, understandable picture of the resilience of life, and of the intimate ballet, point and counterpoint, between physical and biological factors over time in the evolution of our planet.

Steve Cumbaa, Paleobiology, Canadian Museum of Nature

Environmental protection versus trade liberalization: Finding the balance

By Sandra L. Walker. 1993. Publications des Facultes universitaires Saint-Louis, Bruxelles, Belgium, 193 pp. softcover, ISBN 2-8028-0085-X, 650 FB. [Available in Canada from CMD Ltee/1544 rue Villeray/Montreal, Quebec H2E 1H1/Tel: (514) 376-9723/Fax (514) 727-0899.]

If you are a lawyer or a trade bureaucrat and your job depends on understanding the minute details of trade law, you should read this book by Sandra Walker. For others, it is sufficient to know that it is in the reference library. Unlike most books, even those on erudite subjects such as trade law, this one does not tell a readable story centring around the ideas of the author. In fact, the author rarely expresses any opinions or personal thoughts. The book is a step-by-step documentation of legal comments by others on paragraphs, phrases, and individual words that deal with the environment and are found in trade legislation, particularly GATT (now replaced by the WTO), the EEC (now replaced by the EU), and NAFTA.

The subject and presentations are dry, and the re-reading of sentences is almost essential if one wishes to grasp their meaning. For example:

"The weakness of this argument is that a country would still have to show that the measure met the provisos that the measure does not run afoul of the Ad Note to Article III.2 which disallows taxes involving competition 'between, on the one hand, the taxed product and a directly competitive or substitutable product which was not similarly taxed' and of the general non-protectionist requirement of Article III.1."

Convoluted English adds to the problem. By the age of 12, almost every child has been told repeatedly to avoid double negatives. Yet frequently such sentences are found: "Clearly the phrase is not without ambiguity" (rather than "The phrase is ambiguous") and "This sentence is not, however, without limits" (rather than "This sentence is limited") are two examples.

The balance between environmental protection and trade liberalization is a very important topic at a time when freer trade under WTO will reduce customs duties and increase the number of non-tariff trade barriers. Already there are major fights underway where scientific arguments, which are made under the guise of protecting the environment, result in a flood of bureaucratic paperwork. This paperwork nicely replaces taxes and customs duties as trade barriers. At present, topics for dispute include chlorine in pulp and paper products, certification of sustainability in our forests, country specific regulations disguised as environmentally good eco-labels, and regulations on fungal, insect, and parasite in wood and food products. The science behind such issues is not mentioned in the book nor is the rise of pressure from environmental groups, which try to replace science with unsubstantiated emotional beliefs as the criteria on which to determine trade patterns. Without scientific knowledge, the law alone can be quite irrational. Therefore, the absence of these issues from the discussion is serious.

This is one of three books in the field of the environment that I have read recently. The two others were well-written and dealt with exciting topics. I recommend them highly. They are *The Beak of the Finch: A story of evolution in our time* by Jonathan Weiner (1994. Alfred A. Knopf, New York. ISBN 0-679-40003-6) and *The End of Evolution: On mass extinctions and the preservation of biodiversity* by Peter Ward (1994. Bantam Books, New York. ISBN 0-553-08812-2). Even if you are interested very specifically in the link between environment and trade, I would recommend that you read these books rather than Sandra Walker's compendium. They may not help directly with your work, but they will provide you with a greater understanding of the dynamics of evolution and biodiversity. Also, you are bound to be more relaxed when you enter your office on Monday and begin to tackle a problem in the area of environment and trade!

Ian E. Efford, President, Avocet International, 1909 Broadmoor Avenue, Ottawa, Ontario, K1H 5B3 Canada

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Global wetlands: Old world and new

Edited by William J. Mitsch. 1994. Elsevier Science, Amsterdam. 992 pp., ISBN 0-444081478-7, hardcover US $285.50.

When the Fourth Wetlands INTECOL conference was held at Ohio State University in September 1992, the objective was to gather together wetlands experts from both the Old World and the New. When this book was published, it preserved many of the conference's presentations, and it continued on with the same goal.

There are 72 chapters in the book, and although many are authored by North American researchers, there is good representation from other continents. The topics that are covered include biogeochemistry, ecological engineering, wetland creation and restoration, modeling and analysis, and policy and management. Several multi-authored papers offer comparisons between geographically separated wetland ecosystems while elsewhere in the book, the juxtaposition of papers allows the reader to compare research between Old World and New. There is, as well, an unintentional second meaning to the phrase Old World and New, because constructed (or mitigation) wetlands are discussed or mentioned in nearly 20 chapters.

A shortcoming to the book, however, is that there is no mention of management in the title. Clearly, that is the book's focus. There is valuable information on the functions of wetlands, particularly on nutrient cycling, and the extensive reference sections give access to literature that would otherwise be difficult to find. The wetland's function of supporting biodiversity is barely mentioned, however, and the three chapters on conservation are interesting but disappointing. Plants and invertebrates are not considered, nor is the global status given for some of the regionally endangered species.

Although this book does not contribute to our understanding of biodiversity, it does offer valuable information on the more technical functions of wetlands. The book will give decision-makers a greater understanding of the complexities of wetlands systems and will offer managers and academics baseline information for further research.

Irene C. Wisheu, Department of Biology, University of Ottawa, Ontario, Canada, K1N 6N5

Biodiversity in British Columbia: Our changing environment

Edited by Lee E. Harding and Emily McCullum. 1994. Environment Canada, Canadian Wildlife Service, distributed by UBC Press, University of British Columbia, Vancouver. 426 pp., ISBN 0-662-20671-1, softcover, $29.95.

Biodiversity in British Columbia is an impressive volume edited by Lee E. Harding and Emily McCullum and published by Environment Canada. It deals with biodiversity, defined as the diversity of living organisms, a subject of international significance following Canada's signing of the Convention on Biological Diversity in 1992. The book's purpose is to identify large scale changes in and emerging threats to biodiversity in Canada's most western province. It focuses sequentially on a general introduction to the subject, species diversity, ecosystem diversity and prospects for the future. Chapters within each section are written by 20 experts in specific aspects of biodiversity. Written primarily for an audience of experts, the book progresses from author to author, sets an ethical framework, shows noteworthy examples of rare species and protected areas, discusses society's challenges and few successes in managing biodiversity, and leads the reader to conclude that it requires action, not just knowledge, to protect biodiversity in British Columbia.

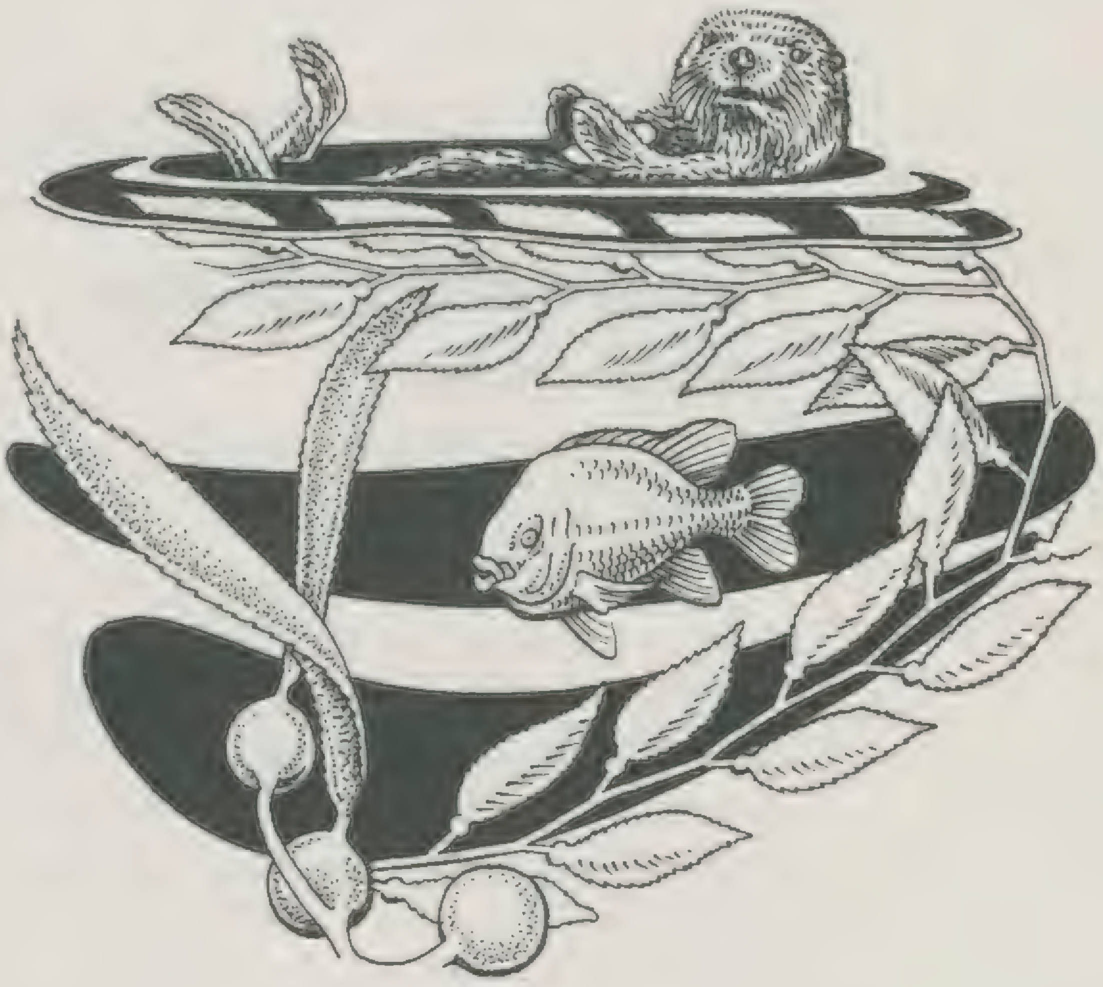
Society must address ethical and other questions. Specifically, do species have a right to exist, whether or not they appear to meet a need of human society? Given that many species are yet to be discovered, how can they be protected? The authors advance that all species have value and that an ecosystem approach to preserving biodiversity may be the most effective.

The volume provides a complete listing of protected areas in B.C. Lists of rare and threatened species are particularly well covered, and some treatments are quite comprehensive with respect to habitat requirements and threats. Evolutionary processes such as speciation are discussed. The discussion includes sticklebacks, which are cited as being more noteworthy than Darwin's examples from Galapogos. Coverage of introduced species shows the potential threats to the native species populations in B.C., although in some instances, major alteration in biodiversity of insects in native habitats is unlikely as a result of inadvertent introductions.

Biodiversity in British Columbia also discusses the impact of society on biodiversity. Examples of negative impacts include sea otter extirpation and the subsequent rise in herbivorous sea urchins populations, previously fed upon by sea otters, which resulted in a reduction of kelp beds. In another chapter it is noted that parks may be subject to high visitation by people who love the outdoors resulting in degradation of natural habitats. Habitat fragmentation by road construction results in smaller and smaller areas of continuous wild refuge required to preserve some wide-ranging species such as caribou.

The authors often argue for increased study and protection of the province's biodiversity. Recommendations are far reaching and even propose conserving ecological gradients to maintain connected habitats as a method of protecting against species loss through possible changes in climate through global warming.

Research and management problems are well documented in this book. It is stated that by the time we know the information required, it may be too late for many species or populations in the province. If species populations are common elsewhere but undocumented, species rarity may be more apparent than real, and therefore, management of land and resources in an area may be based on incomplete information. However, even once confirmed, rarity is not always an indicator of extinction rate or biodiversity loss.



Art courtesy of OceanVoice International, taken from *The Green School Checklist.*

On the positive side of the management issue, recovery teams have been set up for some rare and endangered mammals. The white pelican has even been "delisted" by the Committee on the Status of Endangered Wildlife in Canada.

The detailed information in *Biodiversity in British Columbia* is a challenge for the general reader. Some chapters require an intimate familiarity with the subject since there are no common names for many of the species discussed. Some of the very few maps are poor. One shows 16 different species distributions on one page.

As would be expected from contributions of so many authors, the readability varies from chapter to chapter and there are some difficult transitions between chapters. Restatement of similar information from previous chapters exists, showing the need for smoother editing. Some minor typographical errors also exist, and unfortunately, there is no index reflecting that the compilation was done by adding chapters together without the final synthesis into an integrated text book.

Overall, *Biodiversity in British Columbia* deals with an important subject in a comprehensive way. The individual authors are experts in their field and bring detailed knowledge to a very broad subject. The clear message is that there is a need for more knowledge and a need for action to preserve sensitive areas in the absence of complete knowledge. *Biodiversity in British Columbia* is a recommended addition to any biologist's library.

Grant W. Hughes, Director, Curatorial Services Branch, Royal British Columbia Museum

A biosystematic crisis and a global response to resolve it

By Tecwyn Jones. 1994. *Bulletin of Entomological Research* 84: 443-446.

This editorial reviews the biosystematic crisis occasioned by the acute shortage, and ever-diminishing availability, of biosystematic services for critically important groups of organisms in developing countries. There is an ever-increasing need for these services to support national programs for sustainable agriculture and the use of biodiversity. These services have been provided by scientists and museums in developed countries, now under increased financial constraints, or by expatriates who left the developing country when it achieved independence. These and other problems find a solution in BioNET INTERNATIONAL, a global network dealing with the biosystematics of invertebrates and microorganism crucial to agriculture. BioNET is composed of inter-linked regional networks or LOOPs supported by a consortium of major world centres of excellence, coordinated by a central Technical Secretariat at CAB INTERNATIONAL. The network pools and mobilizes the resources of information, expertise, experience, technologies, and materials of relevant institutions.

An effort is needed to raise the profile of biosystematics and collections in developing and developed countries, and thereby, provide resources for generating the expertise needed for sustainable development, the new biotechnologies, and the global inventory of biodiversity needed for conservation and new uses.

Ethics, religion and biodiversity: Relations between conservation and cultural values

Edited by Lawrence S. Hamilton. 1993. White Horse Press, Knapwell, UK, x + 218 pp., ISBN 1-874267-10-3, paper UK £14.95.

Increasingly it becomes clear that the biodiversity crisis is not primarily one of scientific ignorance but of cultural values and political means. The solutions are not in tinkering at the margins but in making fundamental shifts in these areas. Hence, books with titles like this one are grasped eagerly. The volume is based on a 1991 symposium of the Pacific Science Association, and in his preface and introduction, Hamilton provides an overview of the role of cultural and religious values in conservation efforts, and the ethical statements made and encouraging actions taken to date.

Several chapters address regional case studies. With the treatment of Thai forests as an example, Sponsel and Natadecha-Sponsel do a good job of describing the central features of Buddhism and its subsequent potential for environmental ethics. Similarly, Shengji demonstrates how the Dai community of southwestern China preserves the natural world through holy places. Anson and Raynor recount traditional use of resources in Micronesia; Juvik highlights the differential impact of Christian denominations in the Solomon Islands; and Dudley describes the traditional environmental philosophy of native Hawaiians with its key links among nature, people, and especially chiefs. Senanayake sharply contrasts aboriginal and European use of Australian habitat, with the despoiled land poignantly addressed by one of the former, "oh, you poor bugger." Together these chapters provide some interesting anthropology and occasionally, insights on how to proceed elsewhere.

The more general chapters include one on God and the *Endangered Species Act* by Rolston whose Christian apologetics are vigorous but narrow, and flawed with fashionable but bogus concepts such as "the anthropic principle." In his treatment of biodiversity and ethical development, Goulet is surely correct on the overall need for an ethic of responsibility and related issues such as economic externalities, but there are details with which to quibble (such as, what is Toynbee's evidence that there is an inverse relationship between the cultural and technological attainments of societies?). There are also some major issues to address, the most crucial being that a "parity of moral standing" cannot be maintained between human freedom and the protection of nature. This thorny central problem, that humans must be fettered if nature is to survive, is nowhere firmly grasped.

By far, Weiming's contribution is the finest. Weiming provides an excellent analysis of our heritage from the Enlightenment and of available spiritual sources with which to move toward a global community. The final chapter is a blueprint for research and action by Engel. Certainly action is needed, the plan has benefited from much input, and the theme of building ecological citizenship is worthy. However, the specific proposals appear, perhaps inevitably, bureaucratic and ineffective. This said, if this blueprint can be activated with the understanding exemplified by Weiming, we shall indeed see progress. Overall this book provides both interesting local instances and general considerations with which kind hearts and clear heads must deal with the worsening dilemma before us.

Patrick Colgan, Executive Vice-President, Canadian Museum of Nature

Rare vascular plants in the Northwest Territories. Syllogeus No. 73

By C.L. McJannet, G.W. Argus, and W.J. Cody. 1995. Canadian Museum of Nature, Ottawa. 104 pp. ISBN 0-660-13072-6, paper, CAN $16.00 (in Canada, includes shipping/handling and GST), CAN $18.85 (U.S. and overseas, includes shipping/handling).

This publication is the latest to emerge from the Canadian Rare Plants Project, which is supported by the Research Division of the Canadian Museum of Nature. This annotated list treats 206 rare vascular plant taxa in the Northwest Territories. The publication is divided into three sections. The first includes an introduction, a definition of terms, methods, criteria for assessing rare status, and interpretation of distributional patterns, a summary on the protection of plants in the Northwest Territories, and a listing of future research requirements. The second section is a list of the rare plants and included for each taxon are: documentation supporting its rarity, phytogeography, rare status in other provinces and regions of Canada, the Nature Conservancy Global and Canada Ranks, habitat, relevant comments, and a map illustrating its distribution in the Northwest Territories. The third and final section includes three appendices: a listing by family (Appendix I); a phytogeographical list (Appendix II); and a list of excluded taxa with reasons for their exclusion (Appendix III). [Publisher]

Even ecosystems grow old...

Nature's magnificence is not forever. The Chagos Archipelago contains the largest coral reef atoll in the world, with doughnut-shaped rings of coral fringing turquoise lagoons. Darwin used these islands as a model for his then new theory of the origins of coral reefs. He conceived of volcanic mountains rising majestically from the ocean floor to their full glory, then ponderously subsiding back under the sea. As they rose, coral reefs formed around their volcanic cones. As each mountain sank back into the sea, the corals, which can only form reefs in shallow water, grew furiously toward the surface. As they did, they formed a ring of coral around a bowl of still water, which marked the disappearing tip of the volcanic mountain. Today, only a few tiny coral islands peek through the surface of the water in Chagos.

In 1979, I joined a large group of scientists to explore these fascinating islands, surmising that there might be numerous exotic species on these islands that would occur nowhere else. And indeed, during months of collecting, we discovered thousands of species, many new to science; it seemed our theory was correct. We had discovered a true wealth of diversity, and spent days photographing the species for future publications. By the time we had finished, over forty new species of fish and many more new species of invertebrates were discovered. One of these new species turned out to be a tiny fish—a goby—that is still the smallest known vertebrate animal in the world. But, as we collected, catalogued, and pored over our notes, we realized these magnificent atolls were in decline. What was the likely future for these islands and the underlying coral reef? With world temperatures increasing, there is a threat that rising sea levels may drown low-lying atolls such as these. Based on our investigations, it appears that it will soon not be possible to repeat our work.

These islands are a fascinating source of rich history. In humankind's history the Chagos Archipelago has been a paradise tamed by the labours of prisoners and harvested for its riches; a paradise that has now become a strategic military base. In geological history, mountains formed and sank allowing reefs to grow into massive flourishing atolls. It was as if we had been introduced to a magnificent old person. We imagined the birth and growth of a beautiful youth, the developing maturity of an adult, and now gazed on the comfortable wisdom of an enormous ecosystem in its old age.

Alan R. Emery, Ph.D.
President

A few words about the Canadian Museum of Nature

The origins of the Canadian Museum of Nature (CMN) were formed within the Geological Survey of Canada in 1842. Over 150 years later, the CMN has some 8 million specimens in its collection, which still represents only half the known species in this country, and an active team of scientists, collection managers, education specialists, and business experts.

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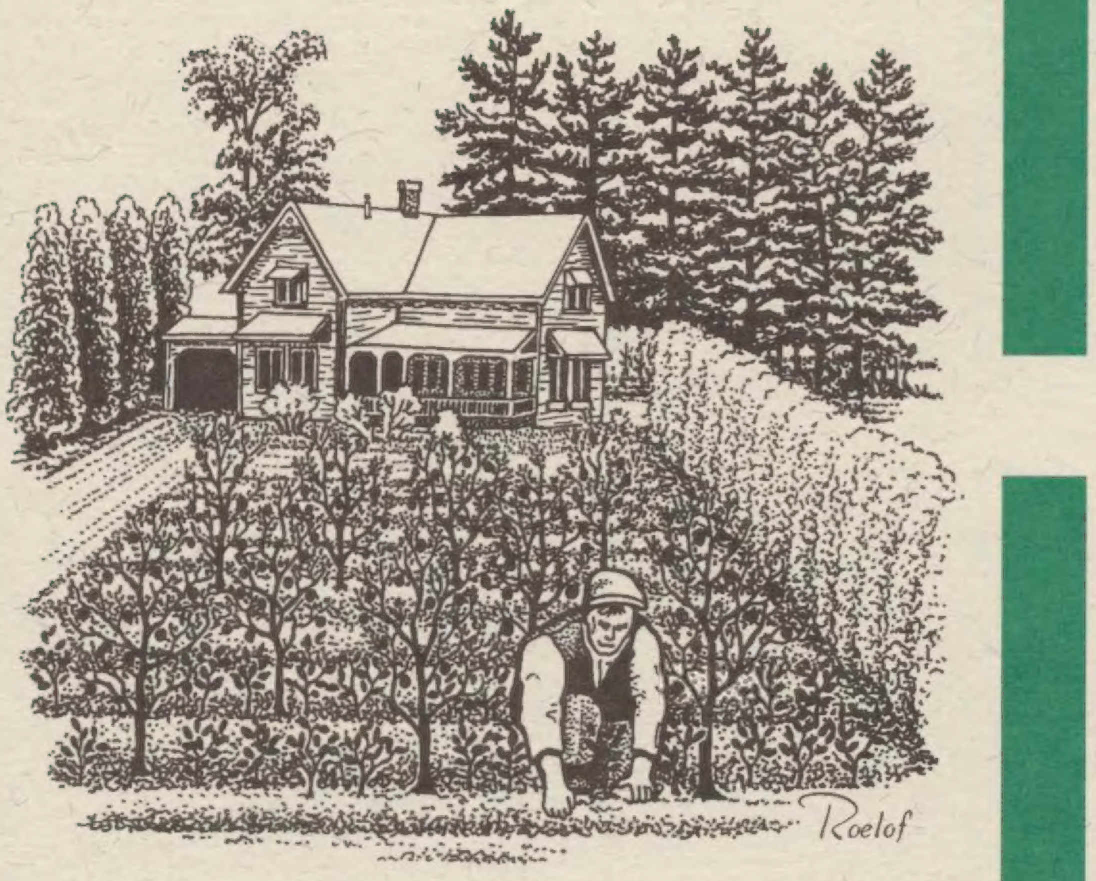

If life on earth is to survive, not a single man, plant, bird or animal must be allowed to lose its life except through some great necessity of life itself. And in the losing all men should join in with every plant and animal and bird to praise it and mourn its passing as that of something infinitely precious that had given life the service for which it had been conceived and rendered itself well.

Laurens van der Post, *A far off place*

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